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SPACE SHUTTLE

AEROTHERMODYNAMIC DATA REPORT

JOHNSON SPACE CENTER

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DATA MANagement services

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EFFECTS OF SURFACE ROUGHNESS ON THE

AERODYNAMIC CHARACTERISTICS OF THE MODIFIED

089 B SHUTTLE ORBITER AT MACH 6

(LA15)

By

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Prepared under NASA Contract Number NAS9-13247

by

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for

Engineering Analysis Division

Johnson Space Center
National Aeronautics and Space Administration
Houston, Texas

WIND TUNNEL TEST SPECIFICS

Test Number: LaRC 20" - 6441
NASA Series No.: LA15
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EFFECTS OF SURFACE ROUGHNESS ON THE AERODYNAMIC CHARACTERISTICS OF THE MODIFIED 089 B SHUTTLE ORBITER AT MACH 6

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SUMMARY

A one hundredth scale model of the modified 089B shuttle orbiter was tested in the Langley 20-Inch Mach 6 tunnel. Force and moment, surface pressure and oilflow data were obtained on one model, figure 2a, and phase-change coating data were obtained on another, figure 2b. The pressure tests were conducted first; the tubes were clipped near the base of the model and then the force and moment and oil flow tests conducted. No pressure data or phase change coating results are presented in this report.

Angles of attack for the tests were from 20° to 35° and are commensurate with the range of flight values from entry down to Mach 5. The design flight Reynolds number at Mach 6, based on model length, was 15 x 10^6, which could not be obtained in the tunnel; therefore, the tests were conducted at the highest and lowest values for this model in the tunnel, 9.4 x 10^6 and 4.0 x 10^6, respectively, to indicate Reynolds number effects. Two control deflection combinations, representative of the bank and pitch control limits of the design flight trajectory, were used. They were $\delta_{e,L} = -10°$, $\delta_{e,R} = 0°$ and $\delta_{e,L} = 14°$, $\delta_{e,R} = 6°$.

The tests were conducted with and without uniformly distributed square roughness pieces to assess the possible effects of raised TPS tiles.

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B) DCY/DB, DCYNDB, DCBLDB vs ALPHA

C) DCY/DA, DCYNDA, DCBLDA vs ALPHA

NOMENCLATURE
General

SYMBOL	SADSAC SYMBOL	DEFINITION
a		speed of sound; m/sec, ft/sec
C_p	CP	pressure coefficient; $(p_l - p_\infty)/q$
M	MACH	Mach number; V/a
p		pressure; N/m^2, psf
q	Q(NSM) Q(PSF)	dynamic pressure; $1/2\rho V^2$, N/m^2, psf
RN/L	RN/L	unit Reynolds number; per m, per ft
V		velocity; m/sec, ft/sec
α	ALPHA	angle of attack, degrees
β	BETA	angle of sideslip, degrees
ψ	PSI	angle of yaw, degrees
ϕ	PHI	angle of roll, degrees
ρ		mass density; kg/m^3, $slugs/ft^3$

Reference & C.G. Definitions

SYMBOL	SADSAC SYMBOL	DEFINITION
A_b		base area; m^2, ft^2
b	BREF	wing span or reference span; m, ft
c.g.		center of gravity
ℓ_{REF} $\bar{c}$	LREF	reference length or wing mean aerodynamic chord; m, ft
S	SREF	wing area or reference area; m^2, ft^2
	MRP	moment reference point
	XMRP	moment reference point on X axis
	YMRP	moment reference point on Y axis
	ZMRP	moment reference point on Z axis

SUBSCRIPTS

b	base
l	local
s	static conditions
t	total conditions
∞	free stream

NOMENCLATURE (Continued)

Body-Axis System

SYMBOL	SADSAC SYMBOL	DEFINITION
C_N	CN	normal-force coefficient; $\frac{\text{normal force}}{qS}$
C_A	CA	axial-force coefficient; $\frac{\text{axial force}}{qS}$
C_Y	CY	side-force coefficient; $\frac{\text{side force}}{qS}$
C_{A_b}	CAB	base-force coefficient; $\frac{\text{base force}}{qS}$ $-A_b(p_b - p_\infty)/qS$
C_{A_f}	CAF	forebody axial force coefficient, $C_A - C_{A_b}$
C_m	CLM	pitching-moment coefficient; $\frac{\text{pitching moment}}{qS\ell_{REF}}$
C_n	CYN	yawing-moment coefficient; $\frac{\text{yawing moment}}{qSb}$
C_ℓ	CBL	rolling-moment coefficient; $\frac{\text{rolling moment}}{qSb}$

Stability-Axis System

SYMBOL	SADSAC SYMBOL	DEFINITION
C_L	CL	lift coefficient; $\frac{\text{lift}}{qS}$
C_D	CD	drag coefficient; $\frac{\text{drag}}{qS}$
C_{D_b}	CDB	base-drag coefficient; $\frac{\text{base drag}}{qS}$
C_{D_f}	CDF	forebody drag coefficient; $C_D - C_{D_b}$
C_Y	CY	side-force coefficient; $\frac{\text{side force}}{qS}$
C_m	CLM	pitching-moment coefficient; $\frac{\text{pitching moment}}{qS\ell_{REF}}$
C_n	CLN	yawing-moment coefficient; $\frac{\text{yawing moment}}{qSb}$
C_ℓ	CSL	rolling-moment coefficient; $\frac{\text{rolling moment}}{qSb}$
L/D	L/D	lift-to-drag ratio; C_L/C_D
L/D_f	L/DF	lift to forebody drag ratio; C_L/C_{D_f}

NOMENCLATURE

ADDITIONS TO STANDARD LIST

SYMBOL	DMS SYMBOL	DEFINITION
C_{Y_β}	DCY/DB	side force coefficient derivative with respect to beta. Algebraic difference of the side force coefficient of two runs divided by the algebraic difference of the sideslip angle of the runs; per degree
C_{n_β}	DCYNDB	yawing moment coefficient derivative with respect to beta. Algebraic difference of the yawing moment coefficient of two runs divided by the algebraic difference of the sideslip angle of the two runs; per degree
C_{ℓ_β}	DCBLDB	rolling moment coefficient derivative with respect to beta. Algebraic difference of the rolling moment coefficient of two runs divided by the algebraic difference of the sideslip angle of the two runs; per degree.
$C_{Y_{\delta_a}}$	DCY/DA	side force coefficient derivative with respect to aileron deflection. Value of side force coefficient with some aileron deflection divided by the value of the aileron deflection; per degree.
$C_{n_{\delta_a}}$	DCYNDA	yawing moment coefficient derivative with respect to aileron deflection. Value of yawing moment coefficient with some aileron deflection divided by the value of the aileron deflection; per degree.
$C_{\ell_{\delta_a}}$	DCBLDA	rolling moment coefficient derivative with respect to aileron deflection. Value of rolling moment coefficient with some aileron deflection divided by the value of the aileron deflection; per degree.
δ_e	ELEVTR	elevator deflection angle, degrees $(\delta_{e_L} + \delta_{e_R})/2$; positive trailing edge down.
δ_a	AILRON	aileron deflection angle, degrees; $(\delta_{e_L} - \delta_{e_R})/2$; positive left trailing edge down.
δ_{e_L}	ELVN-L	left elevon deflection angle, degrees
δ_{e_R}	ELVN-R	right elevon deflection angle, degrees

NOMENCLATURE
ADDITIONS TO STANDARD LIST (Cont.)

SYMBOL	DMS SYMBOL	DEFINITION
δ_r	RUDDER	rudder deflection angle, degrees, positive trailing edge left
δ_{RF}	RUDFLR	rudder flare angle, degrees; for split rudder, included angle/2.
	RGHNSS	parameter name for vehicle surface roughness; value 0.0 indicates no roughness, value 1.0 indicates roughness present.

TEST FACILITY DESCRIPTION

The LaRC 20-inch Mach 6 Tunnel is a blowdown type using air from a 600 psi tank field which is heated by electrical resistance heaters to obtain the desired test conditions. The test Mach number is achieved with a fixed geometry two-dimensional contour nozzle with parallel side walls. The throat is 0.339 x 20.0 inches and the test section, 89.4 inches downstream of the throat, is 20.5 x 20.0 inches. The model was installed with booster centerline at the centerline of the test section, which from previous tests was shown to have a uniform test core of 6.8 x 10 inches at the booster nose and increasing to 12 x 13 inches near the tail.

TEST CONDITIONS

An attempt was made to size the roughness according to the boundary layer properties. In this regard, the boundary layer displacement thicknesses were calculated normal to the wing leading edge using the program developed by Hixon, Beckwith and Bushnell in NASA TMX-2140. Calculated values at both flight and wind tunnel conditions for Mach 6 were found to vary according to the geometric scale of the flight and tunnel models. Similarly, values of boundary layer thickness parameters calculated by Hamilton for the forebody using the methods of AIAA paper 72-703 were found to scale in the same manner. Roughness heights required for transition on the tunnel model wing were computed from North American Aviation Report AFOSR TN60-1164 by Van Driest and Blumer using the displacement thicknesses computed above. These roughness heights (.003" on upper surface and .0015" on lower surface) were larger than the anticipated differences in TPS tile height (.0007") on the wind tunnel model. Since the calculated roughness heights for transition were higher than the expected surface irregularities, an available roughness thickness (.008) was used on all surfaces for convenience and to provide some boundary-layer tripping margin so that the effects of roughness on aerodynamic performance could be determined. Roughness placement is shown in figure 3.

The classical turbulent wedge (see e.g. NASA TMS-2146) was observed behind the placed roughness on the bottom of the body only. No such patterns were apparent on the leeward surfaces or on the bottom wing surface. The .008 roughness was more than sufficient to trip the boundary layer in

the case cited; epoxy residue and surface irregularities, .001" to .003", near the roughness locations caused the turbulent patterns to appear on the body lower surface with the roughness removed. The distance from the roughness element to transition varies inversely with roughness location relative to the longitudinal centerline of the body and is consistent with the trend observed by Morrisette at Langley on a similar model in the same tunnel.

EXPERIMENTAL RESULTS

Neither roughness, sideslip nor Reynolds number was found to have a significant effect on the longitudinal aerodynamic coefficients of the configuration at Mach 6 (see appropriate figures). Therefore assuming that roughness at the highest Reynolds number of the tests is representative of the conditions in flight, one would not expect the aerodynamic performance to be affected by differences in tile height up to an order of magnitude larger than the design tolerances.

Roughness did, however, have an observable effect on the lateral aerodynamic coefficients for up aileron (only side force was strongly affected with down aileron). For the up aileron case, the side force was reduced and the roll and yaw were increased by roughness. These effects are noted to be reduced as Reynolds number is increased (compare control effectiveness plots for the two Reynolds numbers of the tests) and at flight conditions should be less than shown by the data at our highest Reynolds number. Oil flows at $\alpha = 20°$ with aileron up show only slight changes in the surface flow patterns over both the windward and leeward surfaces when roughness

was added. Examination of the surface pressure measurements, however, shows that roughness effects on the roll and yaw are caused by quasi-uniform changes in pressure over both surfaces of the wing and elevon. For up aileron the pressure on the upper surface is increased about half as much as the pressure is reduced over the lower surface. The two changes together cause an overall increase in roll effectiveness and in yaw. For down aileron, however, the pressure in general is reduced over the upper surface as well as on the lower surface, which reduces the roughness effect on roll and yaw. The effect of roughness on side force and yaw are not totally discernable in the pressure distribution over the upper and lower surfaces because the body side pressure and center of pressure variation due to roughness influence those two parameters.

Lateral and directional stability also reflect the effect of roughness. The effect tends to increase with Reynolds number and, therefore, may be larger at flight conditions. The effects of roughness on these stabilities, however, are observed to be nearly constant over the angle of attack range, making it somewhat easier to correct with augmentation.

No hysteresis effects of boundary-layer separation and reattachment were observed in the data when points were repeated by traversing the angle of attack range from the opposite direction.

DATA REDUCTION

Six component force and moment data recorded by the internal strain gauge balance were reduced to coefficient form using standard data reduction procedures. Reference dimensions used were:

S_{REF} = wing planform area = 38.736 sq. in.

$\ell_{REF} = \bar{c}$ = wing mean aerodynamic chord = 4.748 inches

b_{REF} = wing span = 9.367 inches

Moments are about a reference c.g. location 8.507 inches aft of the model nose.

Base pressure measurements were recorded and used to determine a base axial force coefficient, which was applied as a correction to balance recorded axial force.

CONCLUDING REMARKS

The purpose of this investigation was to determine the variation of aerodynamic performance and stability and control of the 089B Shuttle Orbiter with changes in boundary-layer characteristics resulting from TPS tile height differences on the vehicle in flight. To do this, the wind tunnel data at Mach 6 for the configuration without roughness were compared with data for the configuration with discrete roughness squares paralled to and near the wind leading edge and on the forward part of the body. The roughness squares were scaled according to the TPS tile size and had a height that was an order of magnitude greater than the tolerance for tile height difference.

Boundary-layer type

The boundary-layer calculation for the body portion, using the shuttle criteria for transition, indicated that natural transition would occur in flight on the lower surface at Mach 6 near the placed roughness

squares but would not occur in the wind tunnel at 2/3 flight Reynolds number. In the wind tunnel test at 2/3 flight Reynolds number, however, roughness particles and surface irregularities slightly larger than anticipated tile height differences tripped the boundary layer. Therefore, transition is expected to occur on the body lower surface in flight at Mach 6 with or without tile height variations.

No transition criteria was applied to the boundary-layer calculations for the wing, and the wind tunnel results with roughness squares do not show transition at 2/3 flight Reynolds number. Therefore, the wing boundary-layer is expected to be laminar in flight at Mach 6 on a smooth model. Whether tile height difference will trip the wing boundary-layer in flight is not answered by these tests.

Longitudinal aerodynamics

For up aileron the control effectiveness was, in general, increased by roughness. However, the effect is reduced as Reynolds number is increased from 1/4 to 2/3 of full scale and, if the trend continues, would be minimal at flight Reynolds numbers. For down aileron the effect of roughness is insignificant at all Reynolds numbers.

Lateral and directional stability

The effect of roughness on lateral and directional stability is insignificant at Reynolds number 1/4 of full scale; however, roughness reduces both stabilities at 2/3 of full scale Reynolds number and, if the trend continues, could become significant at full scale. The effect is uniform with angle of attack, however, making it somewhat easier to correct with augmentation.

TABLE I.

Sheet 1 of 2

TEST: LARC 20"-6441 (LA-15)

DATA SET/RUN NUMBER COLLATION SUMMARY

DATE: 10/11/73

DATA SET IDENTIFIER	CONFIGURATION	SCHD. α	SCHD. β	δ_{EL}	δ_{ER}	δ_e	δ_a	[illegible]	RN/L	MACH NUMBERS 6.0
RPH001	089B ORB w/MOD	A	0	-10	0	-5	-5	0	9.4	63
02	NOSE - w/o BARS							1		44
03			-5					0		64
04								1		49
05			0	14	6	10	4	0		59
06								1		53
07			-5					0		60
08								1		54
09			0	-10	0	-5	-5	0	4.0	67
10								1		47
11			-5					0		68
12								1		52
13			0	14	6	10	4	0		62
14								1		57
15			-5					0		61
16								1		58

1 7 13 19 25 31 37 43 49 55 61 67 75 76

BETA ALPSI) CN CAF CLM CBL CYN CY CAB MACH ALPHA

COEFFICENTS IDVAR (1) IDVAR (2) NDV

α OR β SCHEDULES

A) 20°, 25°, 30°, 35°

ROUGHNESS
OFF = 0
ON = 1

TABLE I. (CONTINUED)

Sheet 2 of 2

TEST: LARC 20"-6441 (LA-15)

DATA SET/RUN NUMBER COLLATION SUMMARY

DATE: 10/11/73

DATA SET IDENTIFIER	CONFIGURATION	SCHD. α	SCHD. β	PARAMETERS/VALUES δ_{eL}	δ_{eR}	δ_e	δ_a	[illegible]	RN/L					NO. OF RUNS	MACH NUMBERS	6.0		
RPH017	089B ORB w/MOD.	B	0	-10	0	-5	-5	0	4.0							75		
18	NOSE - W/O OMS	B	0	-30	-30	-30	0	0	4.0							78		
19	↓	B	5	-30	-30	-30	0	0	4.0							80		

TEST RUN NUMBERS

1 7 13 19 25 31 37 43 49 55 61 67 75 76

BETA A(PSI) CN CAF CLM CBL CYN CY CAB MACH ALPHA

COEFFICENTS IDVAR (1) IDVAR (2) NDV

α OR β SCHEDULES B) 0°, -10°, -15°, -20°, -25°

Notes:

1. Positive directions of force cofficients, moment coefficients, and angles are indicated by arrow
2. For clarity, origins of wind and stability axes have been displaced from the center of gravity

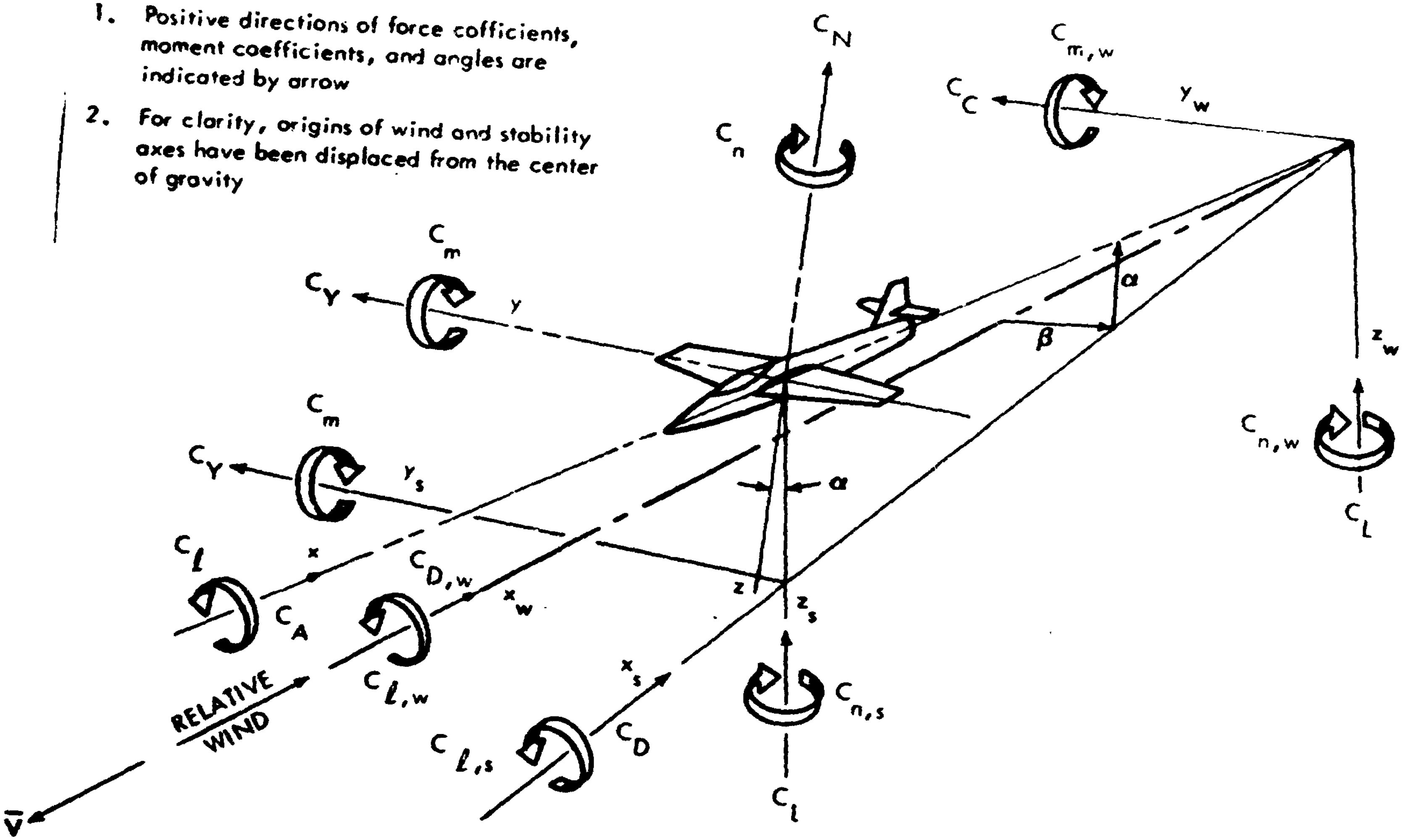
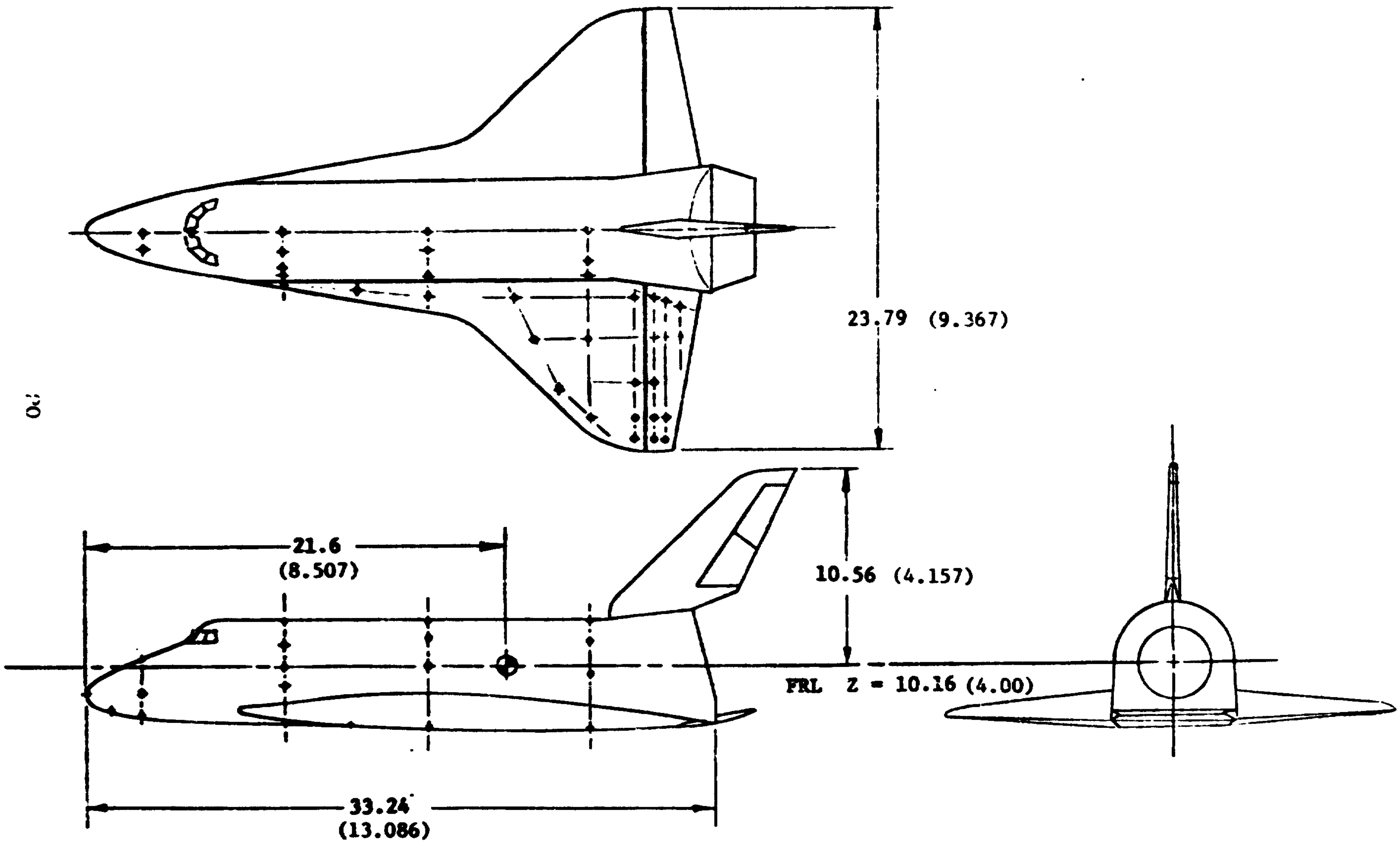
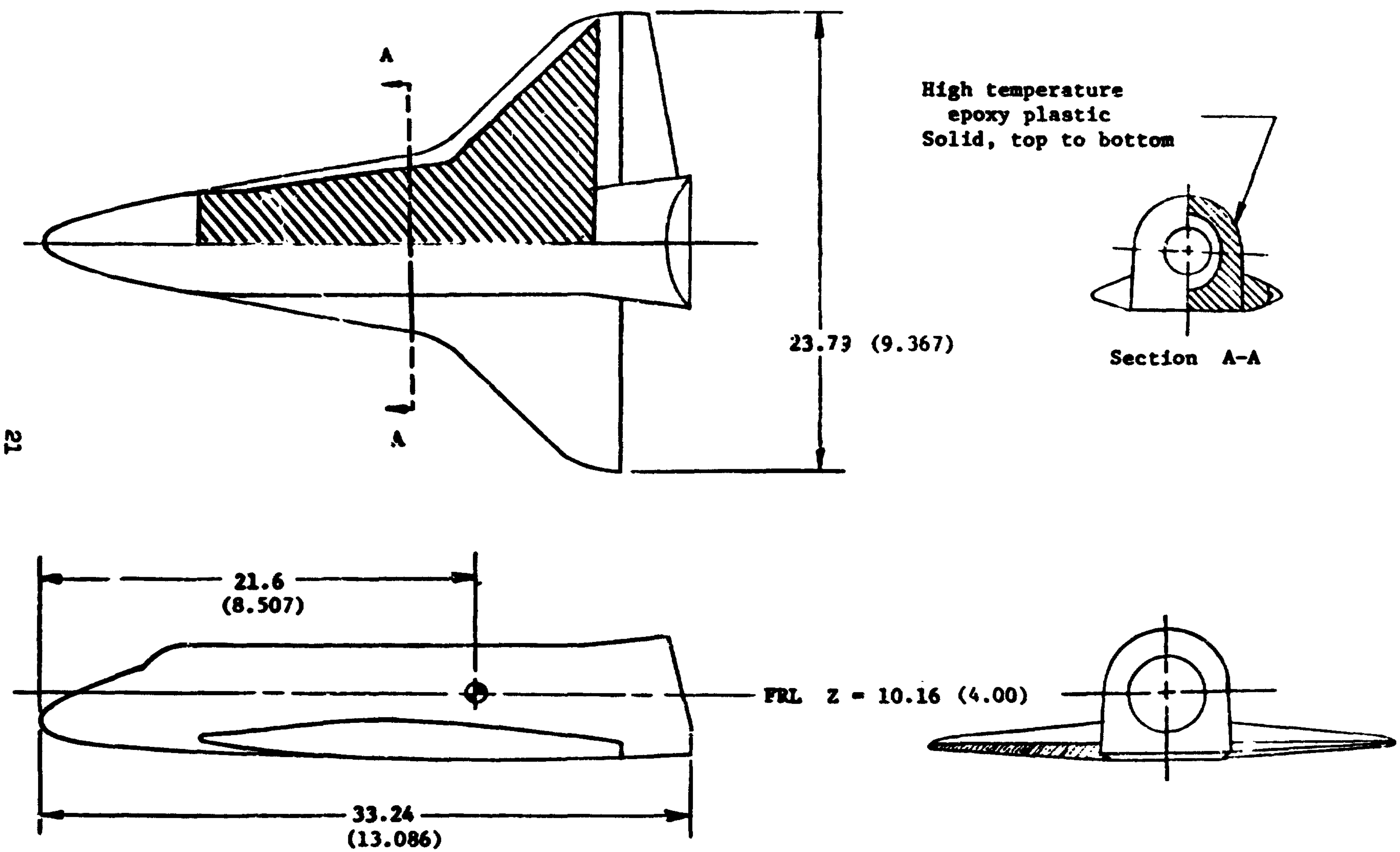


Figure 1. - Axis Systems.



(a) Pressure, force and oil flow

Figure 2.- One-hundredth scale model of modified 089B shuttle orbiter showing orifice locations. All dimensions in centimeters (Inches)



(b) Phase change coatings

Figure 2.- Concluded.

[redacted]

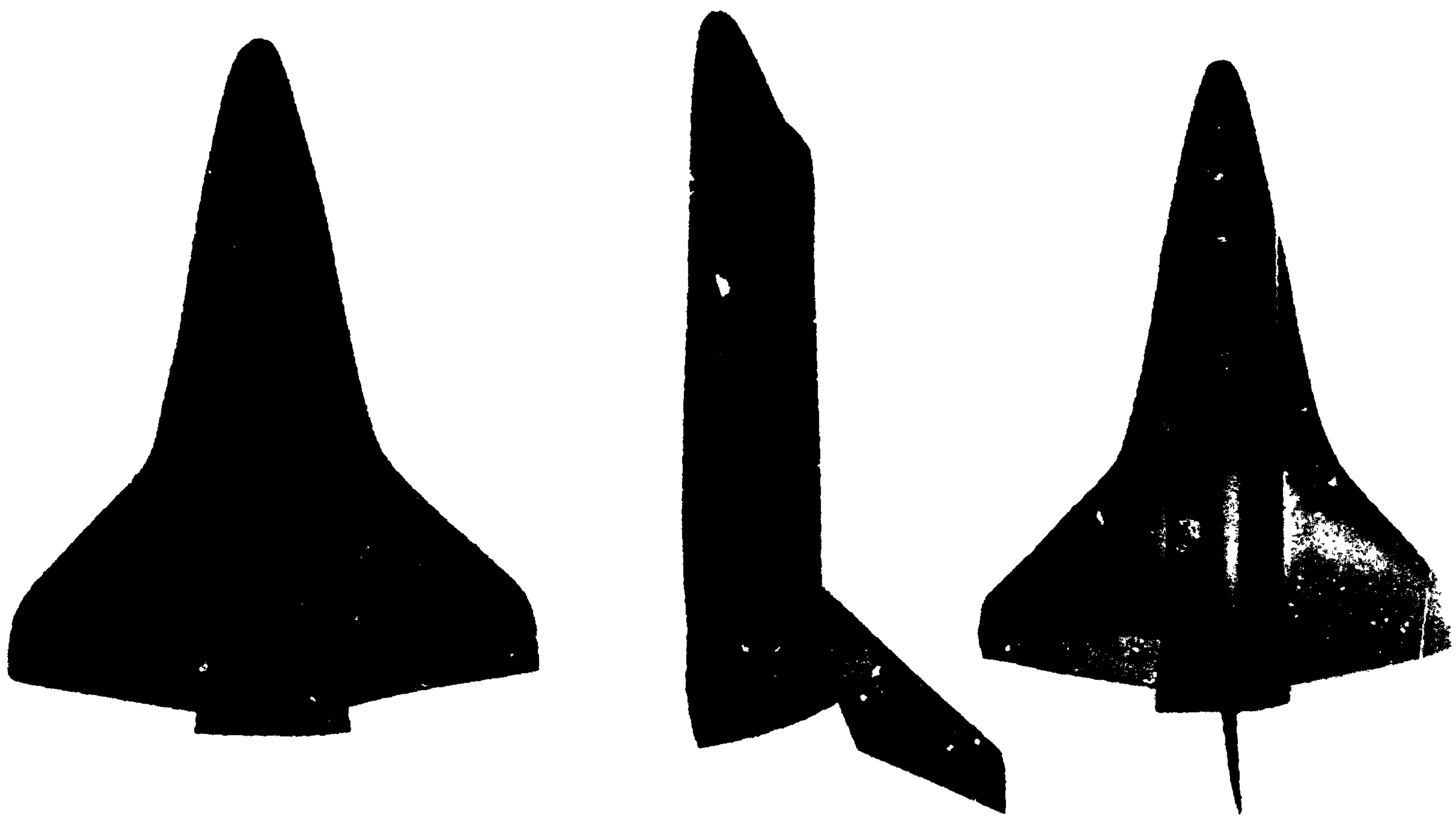


FIGURE 3. ROUGHNESS LOCATIONS ON 089B ORBITER IN LANGLEY MACH 6 TUNNEL

DATA FIGURES

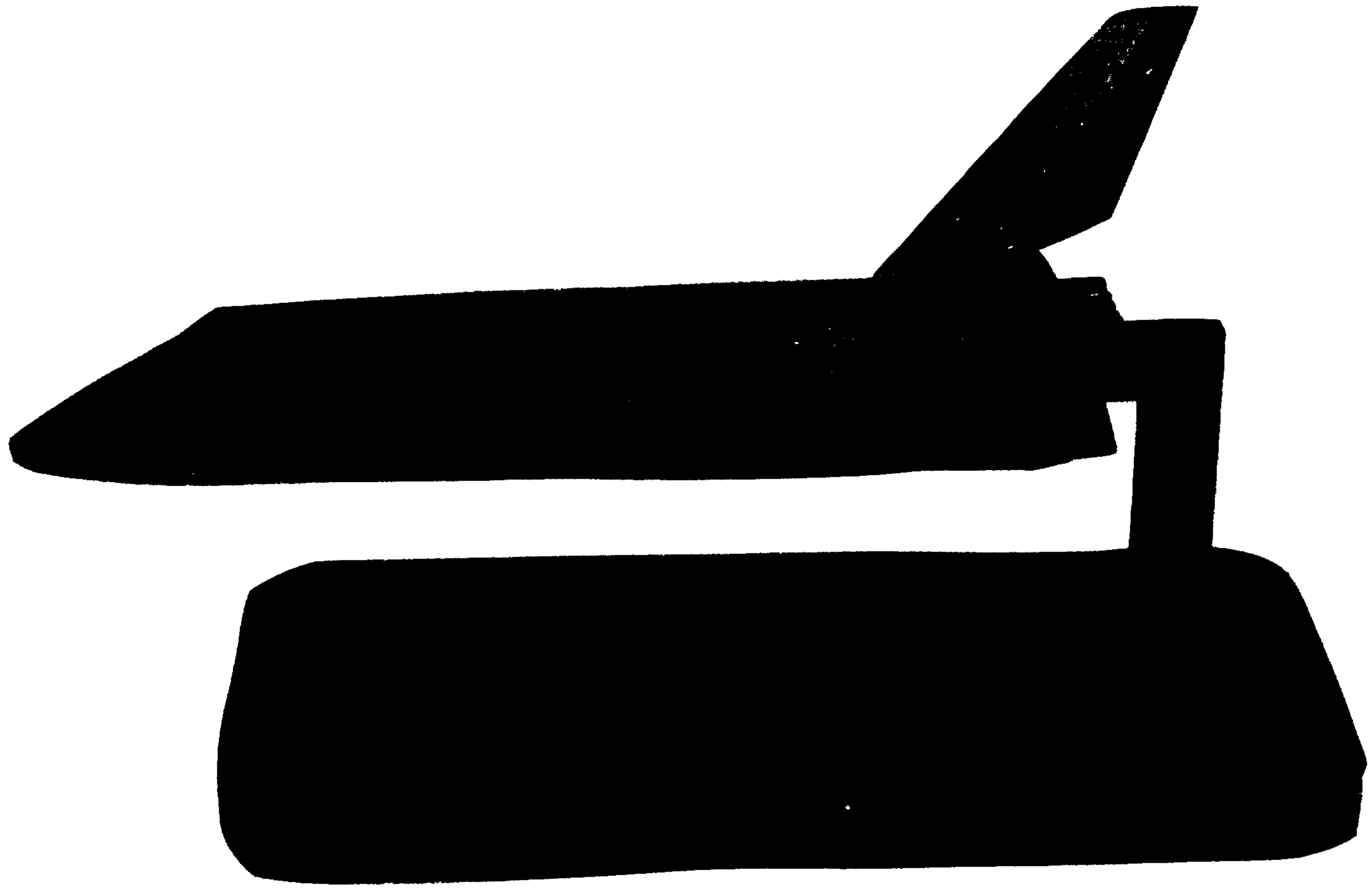


FIGURE 1. .01 SCALE MODIFIED ROCKWELL (089B) ORBITER CONFIGURATION SHOWING LOCATIONS OF .0625" x .0625" x .008" ROUGHNESS SQUARES

A. SIDE VIEW

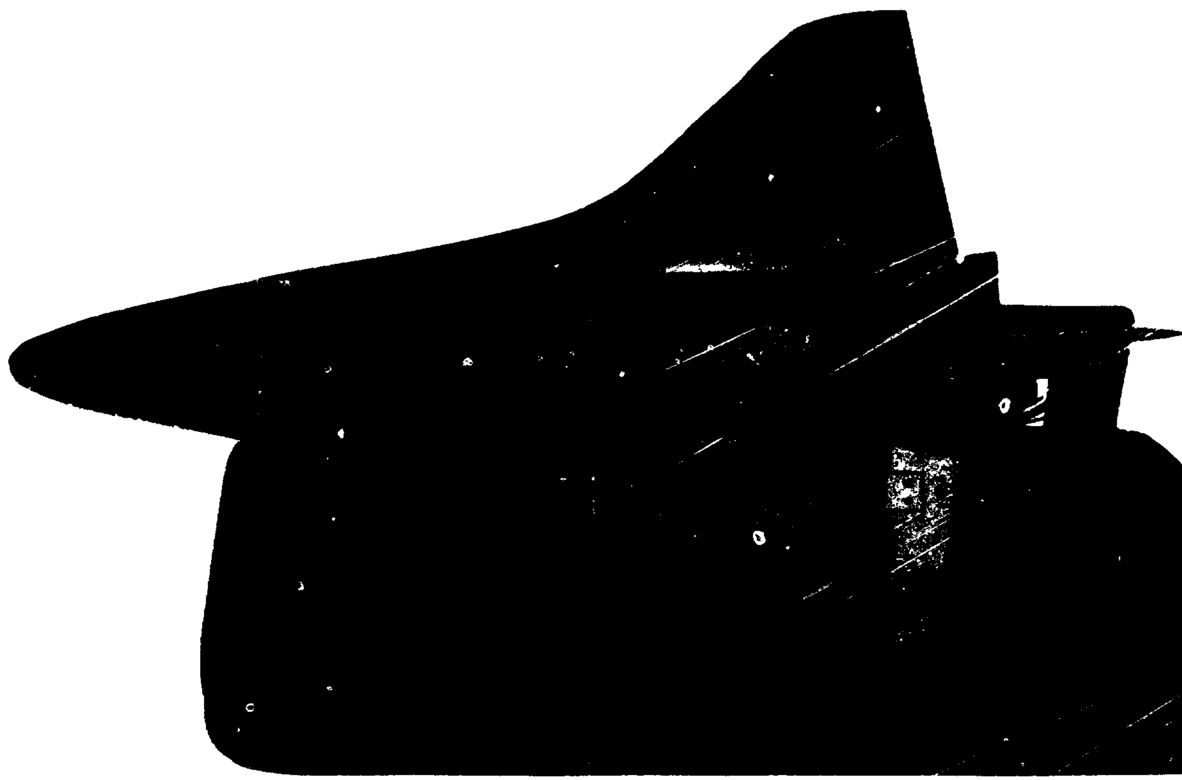


FIGURE 1. (CONTINUED)

B. TOP VIEW

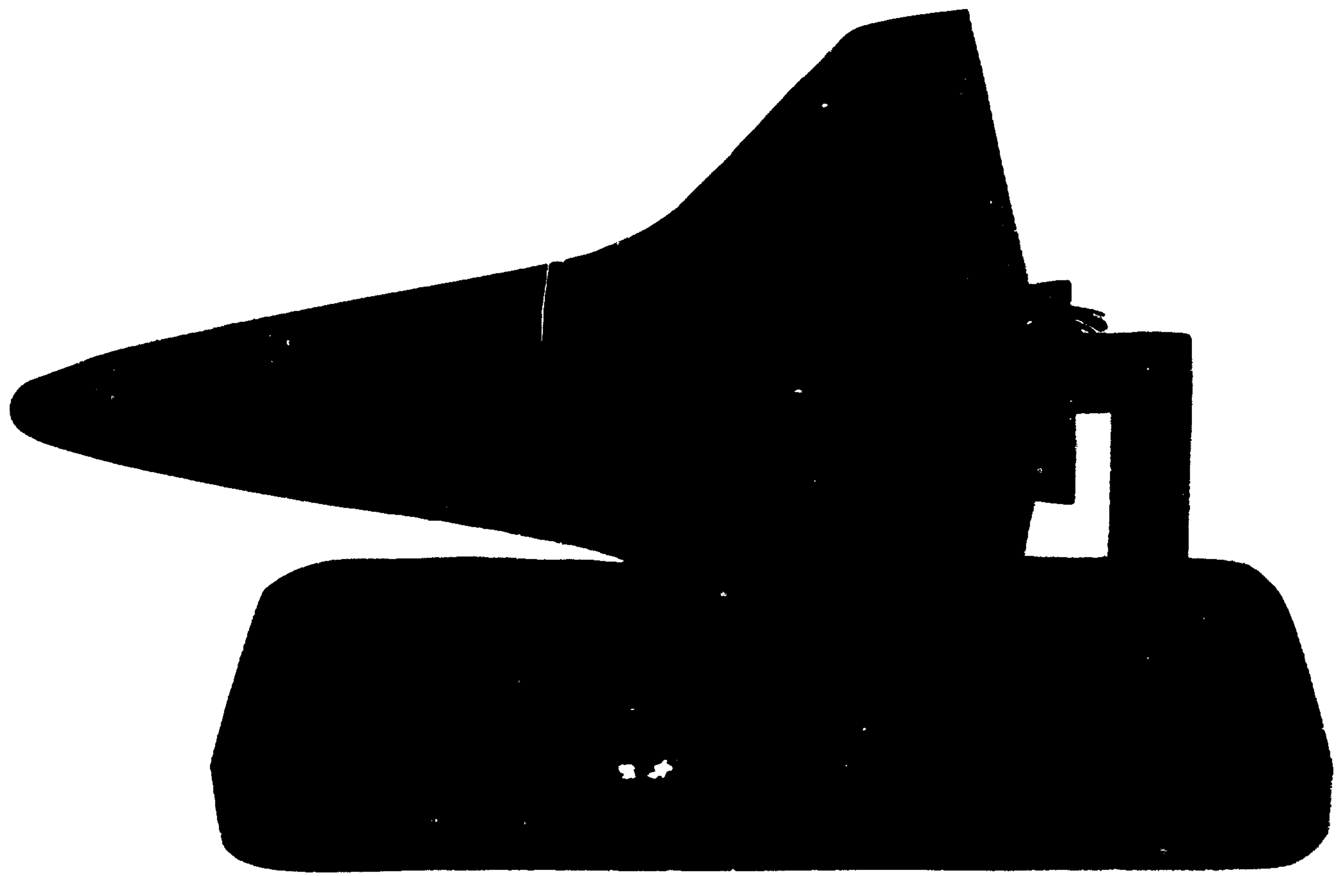


FIGURE 1. (CONTINUED)

C. BOTTOM VIEW

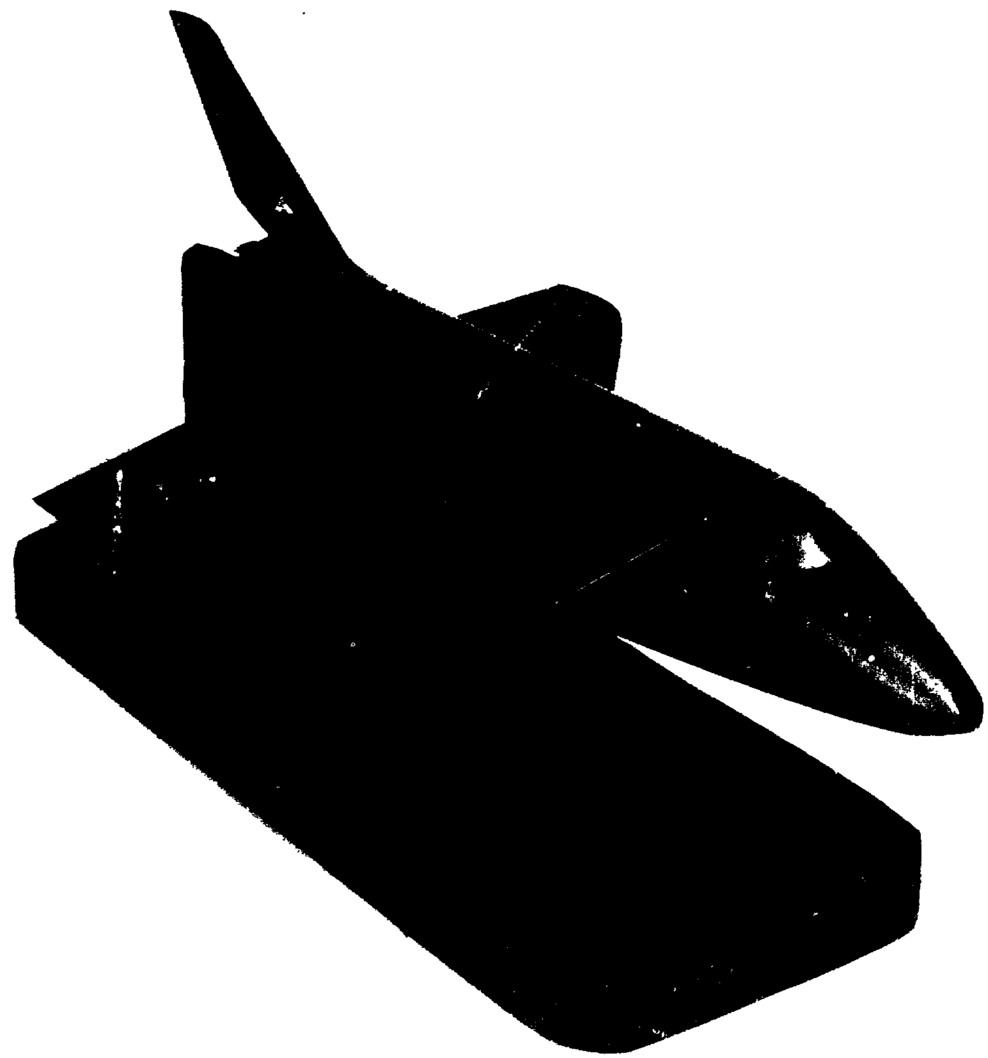


FIGURE 1. (CONTINUED)

D. FRONT-OBLIQUE VIEW

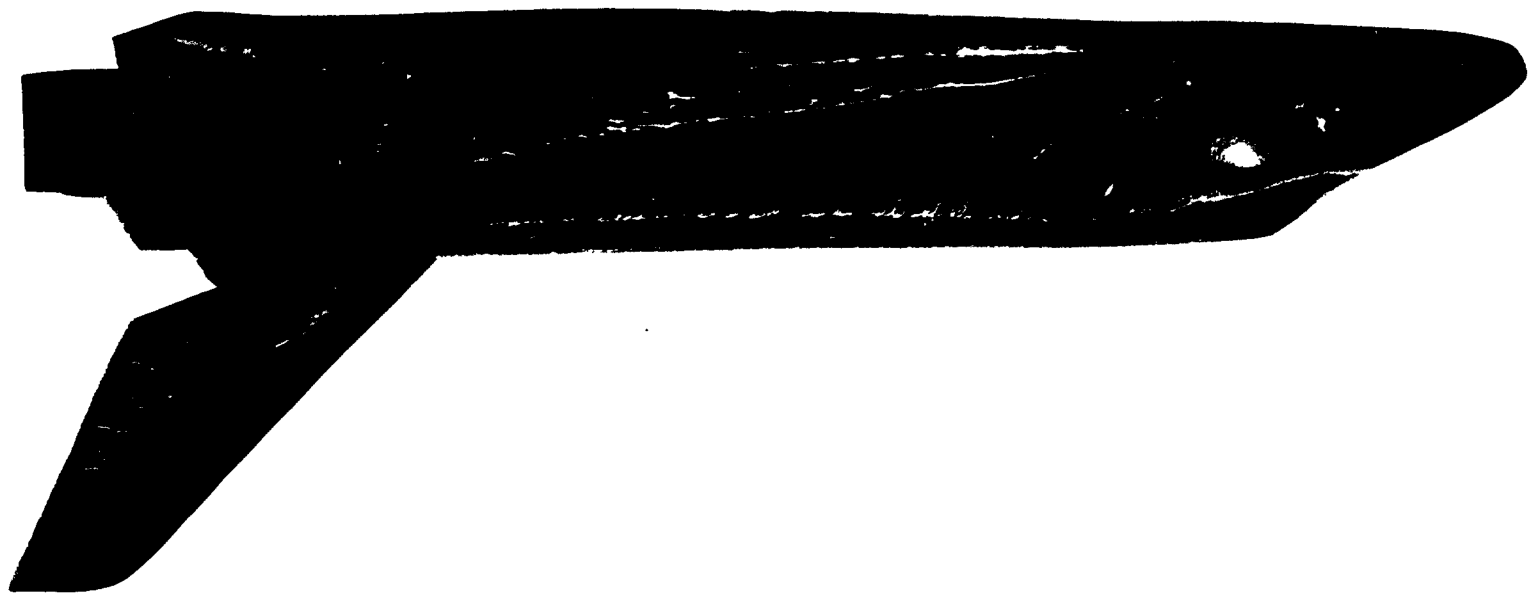


FIGURE 2. OIL FLOW PATTERNS ON THE .01 SCALE MODIFIED ROCKWELL (089B) ORBITER CONFIGURATION AT $\alpha = 20°$, $\beta = 0°$, $\delta_{e_L} = -10°$, $\delta_{e_R} = 0$, RN/L = 9.4×10^6, ROUGHNESS OFF

A. LEFT SIDE VIEW

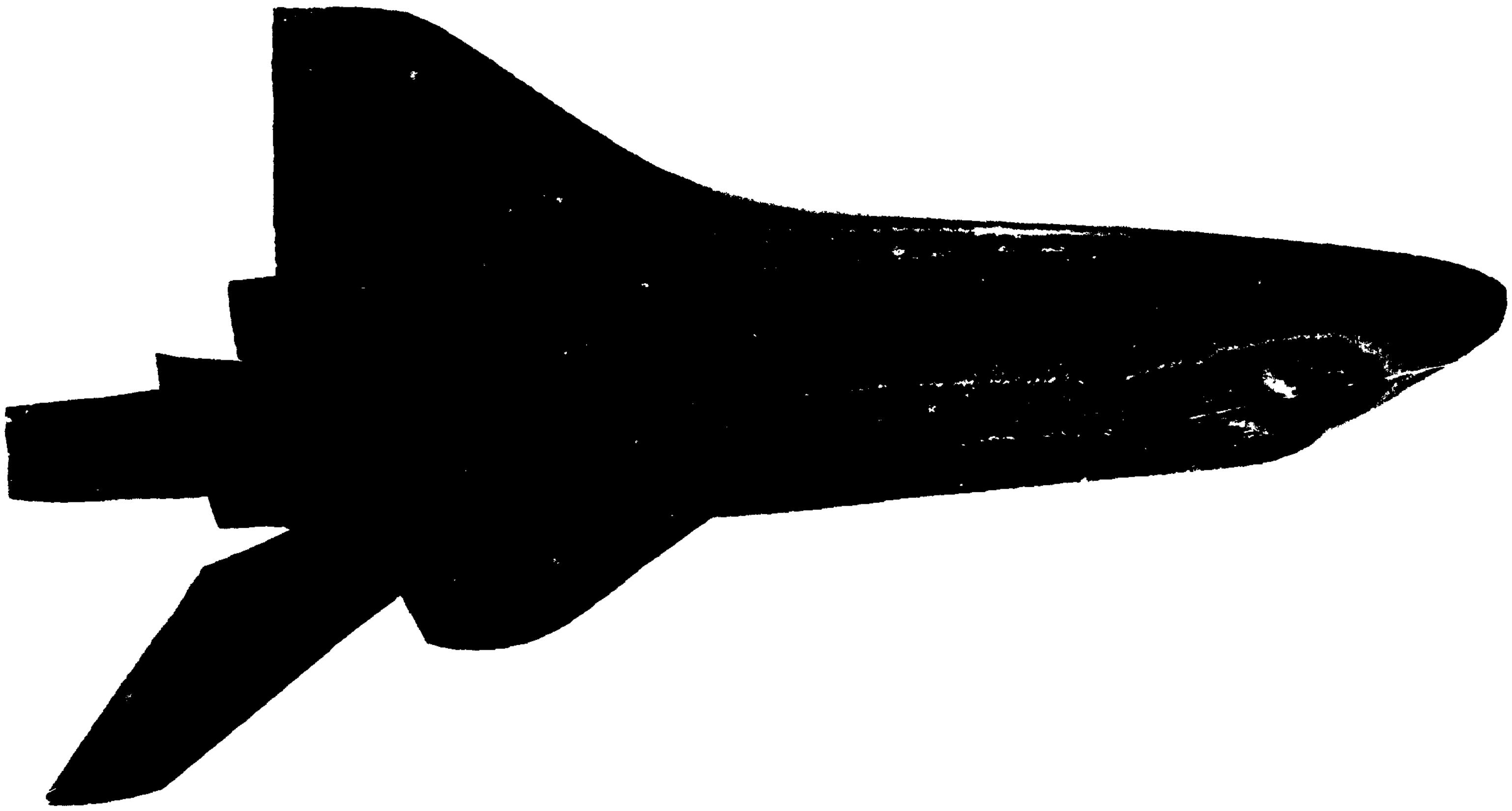


FIGURE 2. (CONTINUED)

B. LEFT WING-BODY JUNCTION VIEW

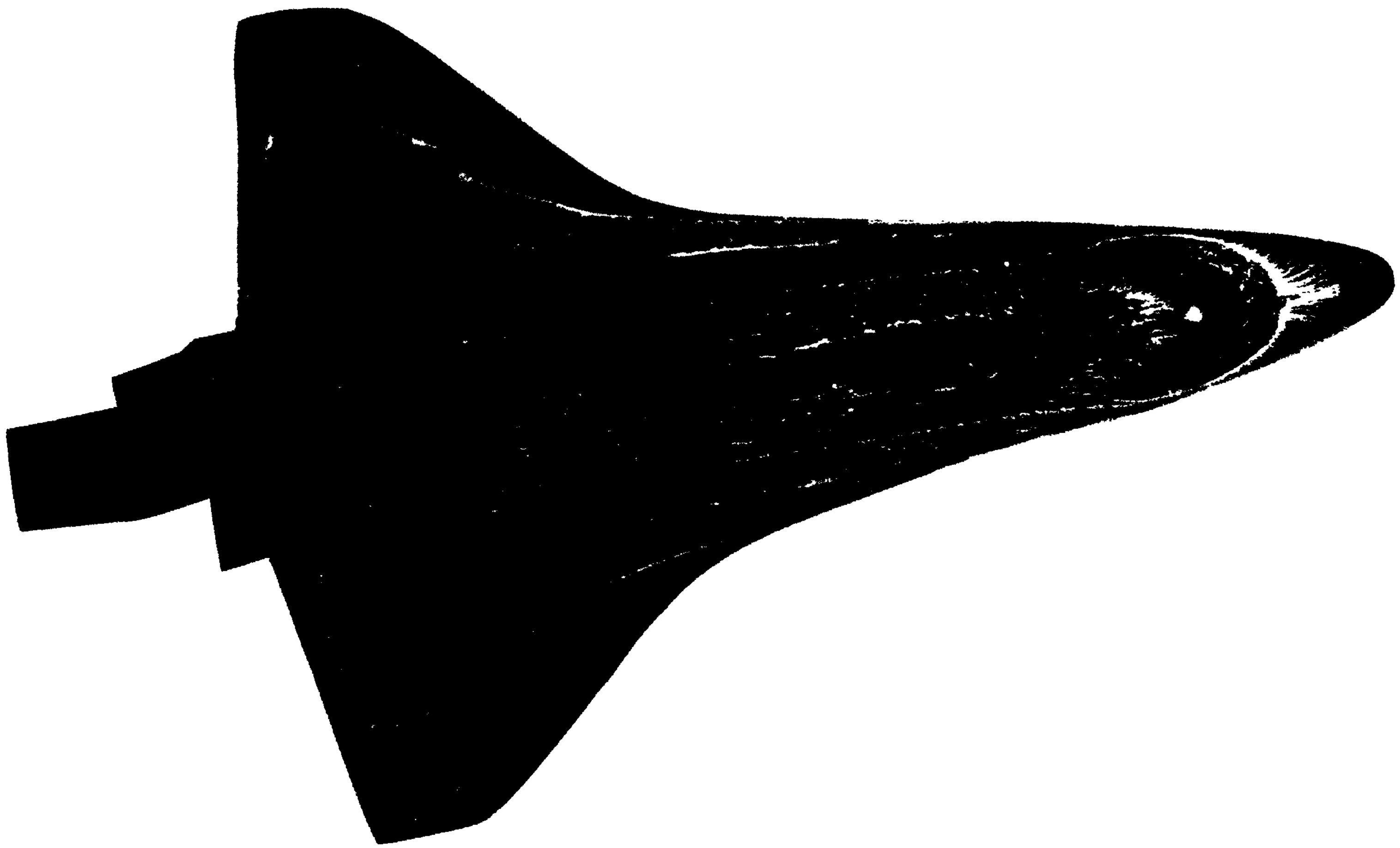


FIGURE 2. (CONTINUED)

C. TOP VIEW

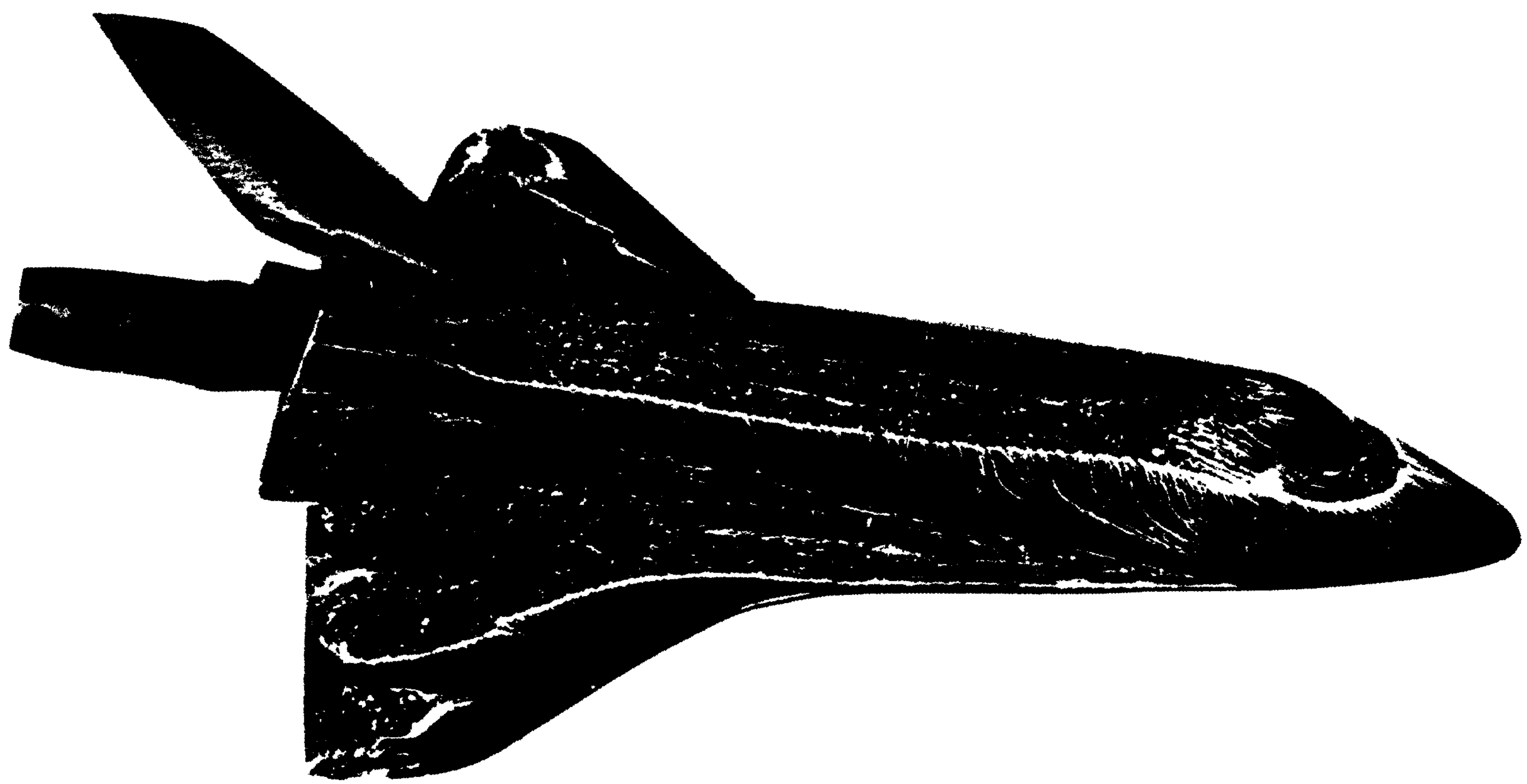


FIGURE 2. (CONTINUED)

D. RIGHT WING-BODY JUNCTION VIEW

FIGURE 2. (CONTINUED)

E. RIGHT SIDE VIEW

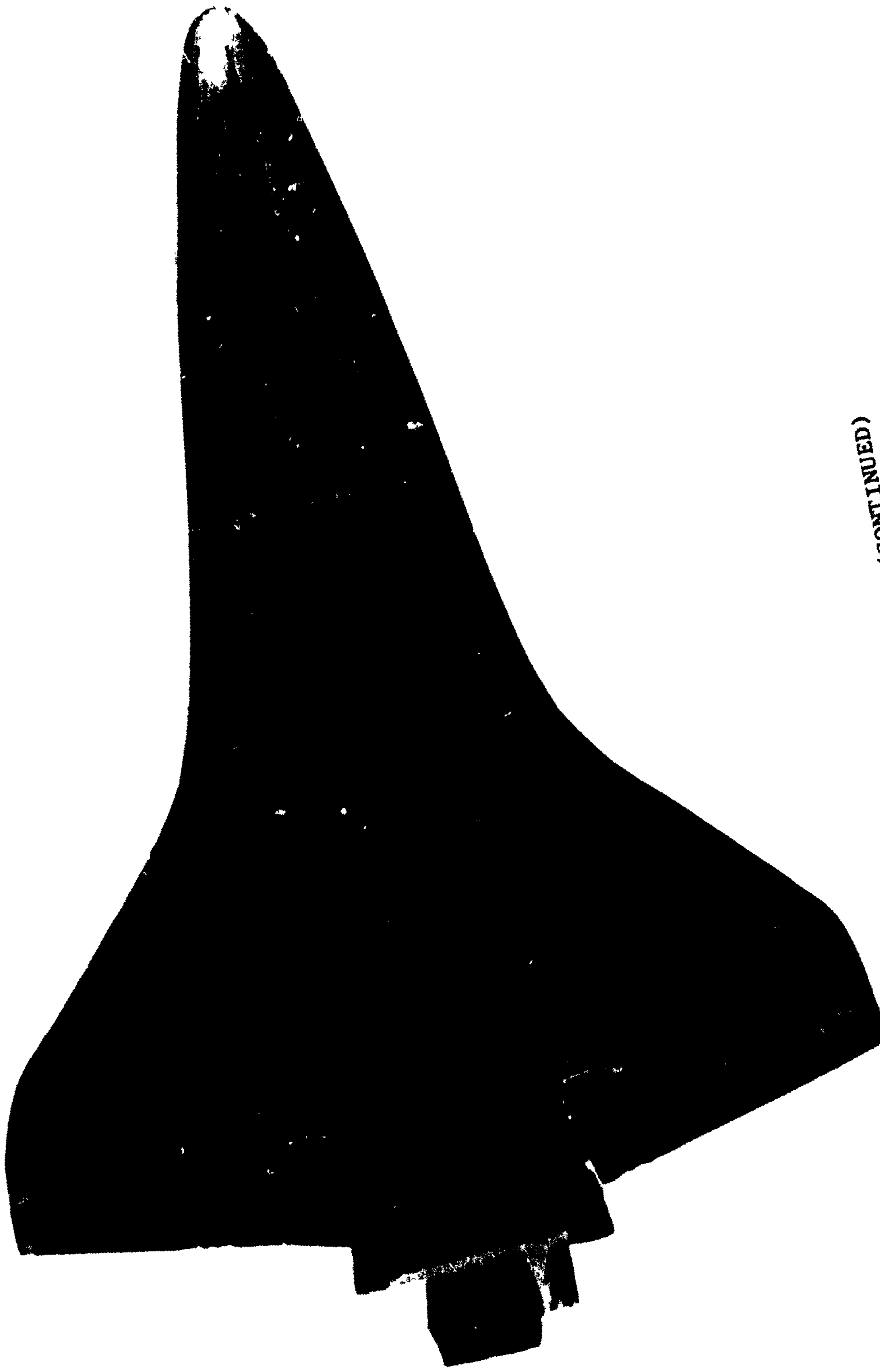


FIGURE 2. (CONTINUED)

F. BOTTOM VIEW

FIGURE 3. OIL FLOW PATTERNS ON THE .01 SCALE MODIFIED ROCKWELL (089B) ORBITER CONFIGURATION AT $\alpha = 20°$, $\beta = 0°$, $\delta_{e_L} = -10°$, $\delta_{e_R} = 0$, RN/L = 9.4×10^6, ROUGHNESS ON

A. LE[illegible] SIDE VIEW

FIGURE 3. (CONTINUED)

B. LEFT WING-BODY JUNCTION VIEW

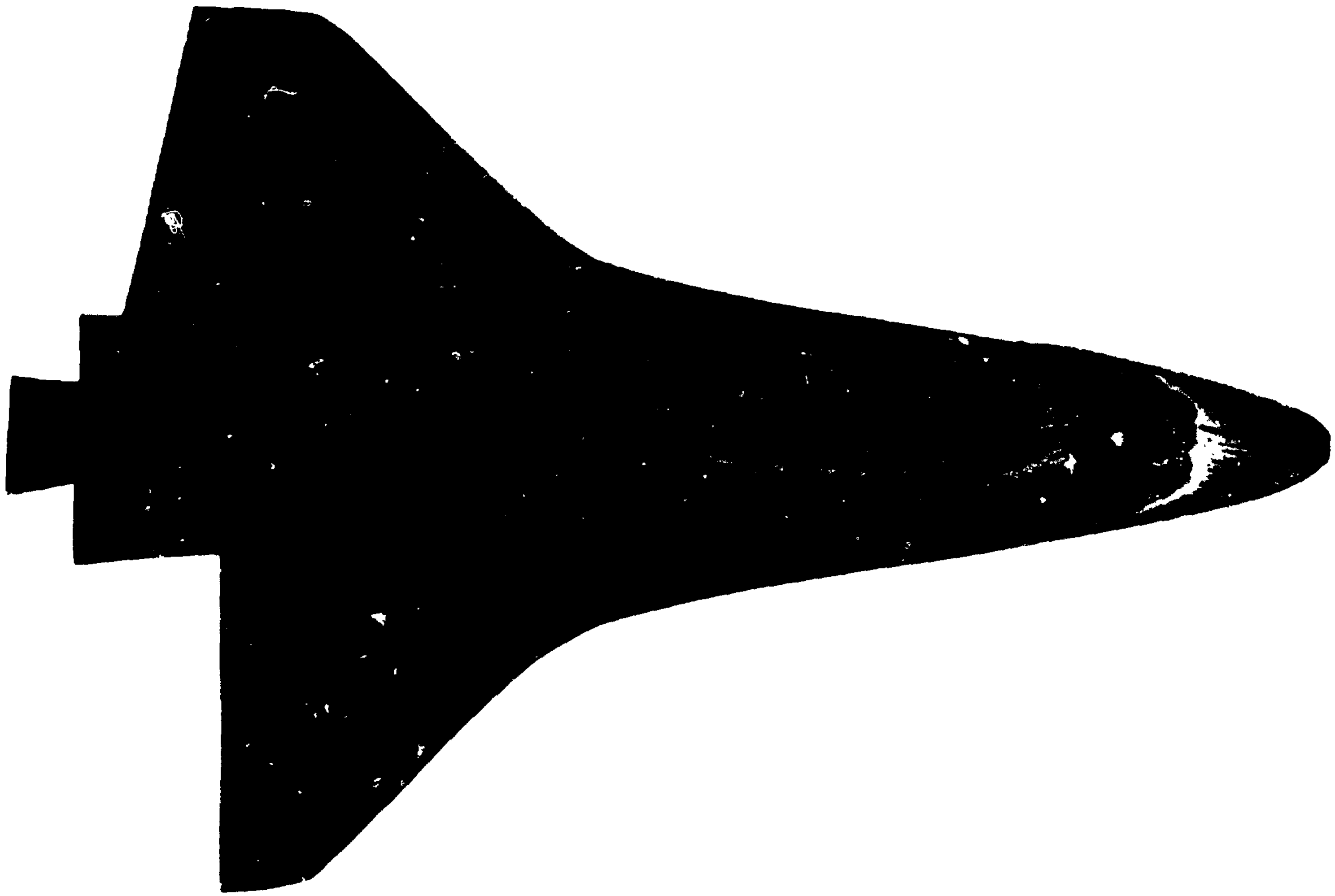


FIGURE 3. (CONTINUED)

C. TOP VIEW

FIGURE 3. (CONTINUED)

D. RIGHT WING-BODY JUNCTION VIEW

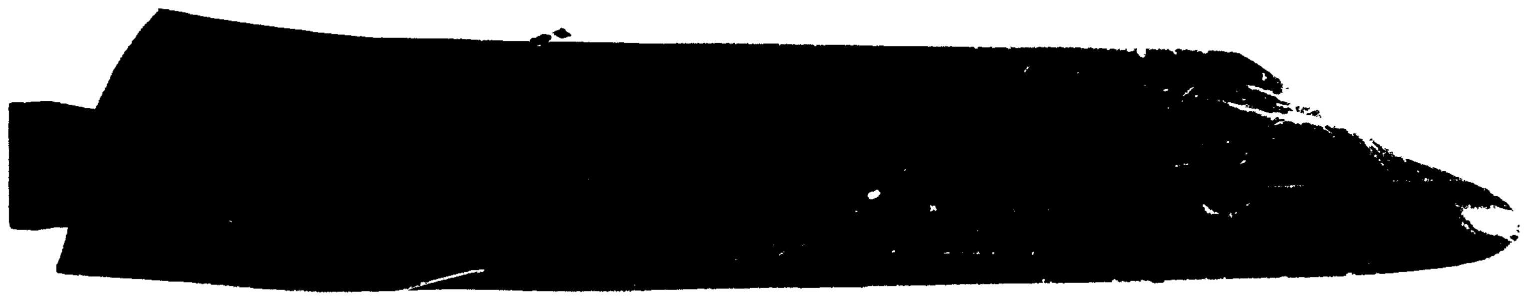


FIGURE 3. (CONTINUED)

E. RIGHT SIDE VIEW

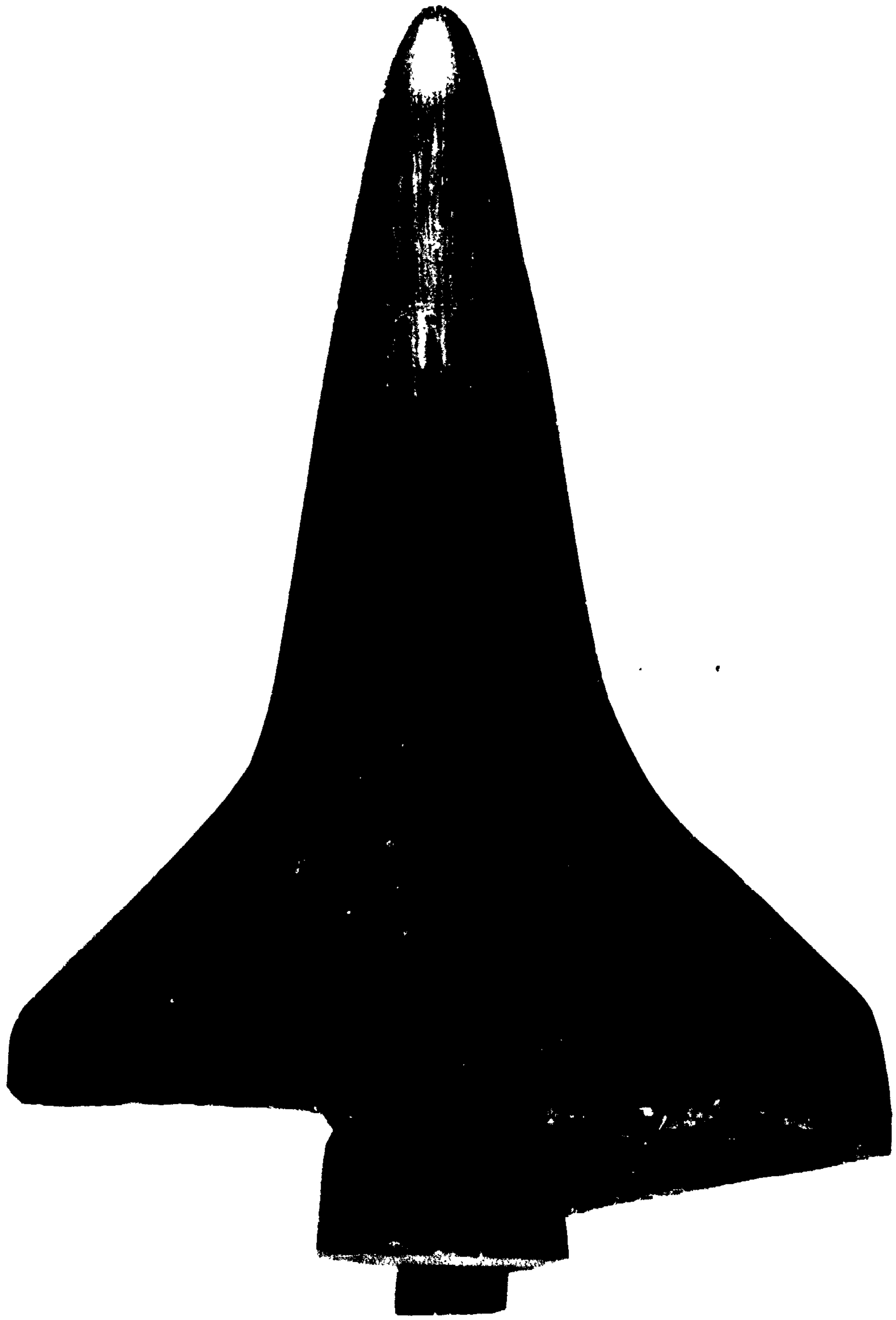


FIGURE 3. (CONTINUED)

F. BOTTOM VIEW

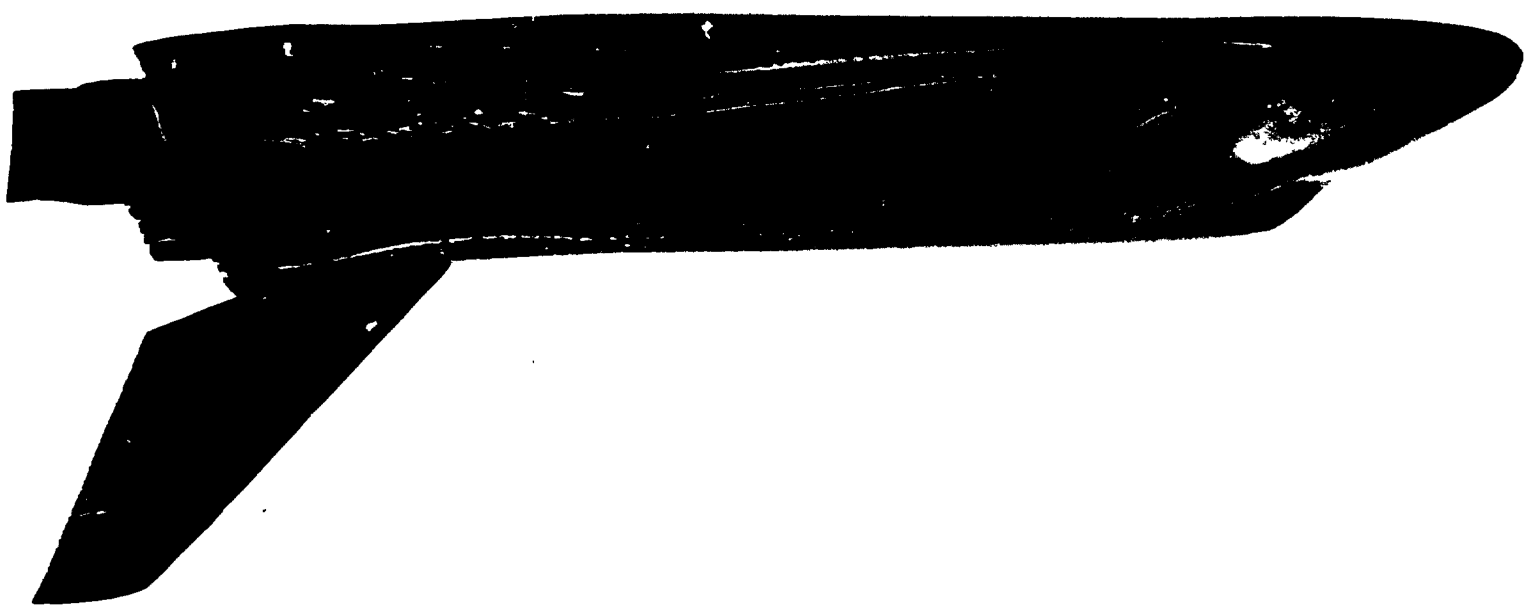


FIGURE 4. OIL FLOW PATTERNS ON THE .01 SCALE MODIFIED ROCKWELL (089B) ORBITER CONFIGURATION AT α = 20°, β = -5°, δ_{e_L} = -10°, δ_{e_R} = 0°, RN/L = 9.4 x 10^6, ROUGHNESS OFF

A. LEFT SIDE VIEW

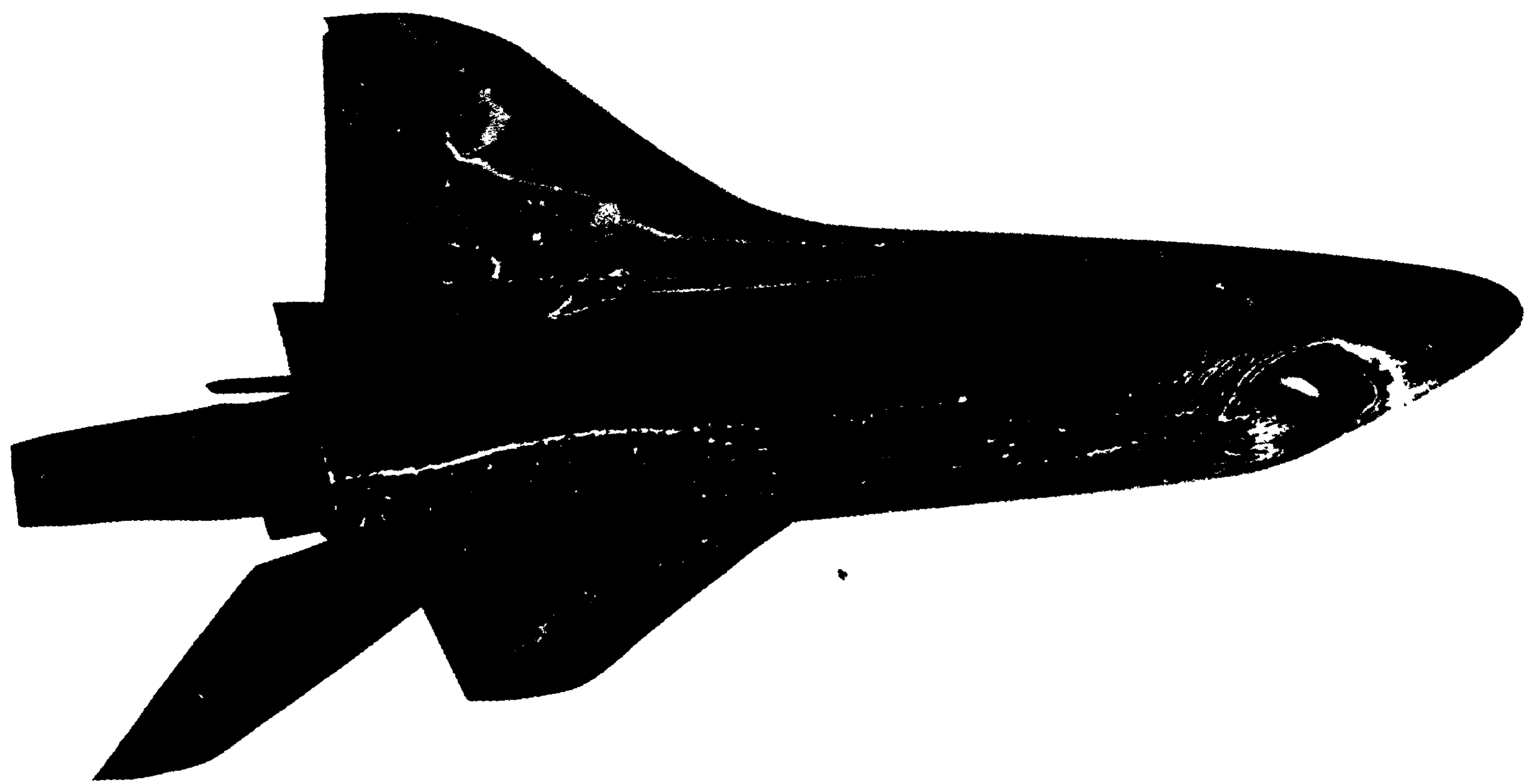


FIGURE 4. (CONTINUED)

B. LEFT WING-BODY JUNCTION VIEW

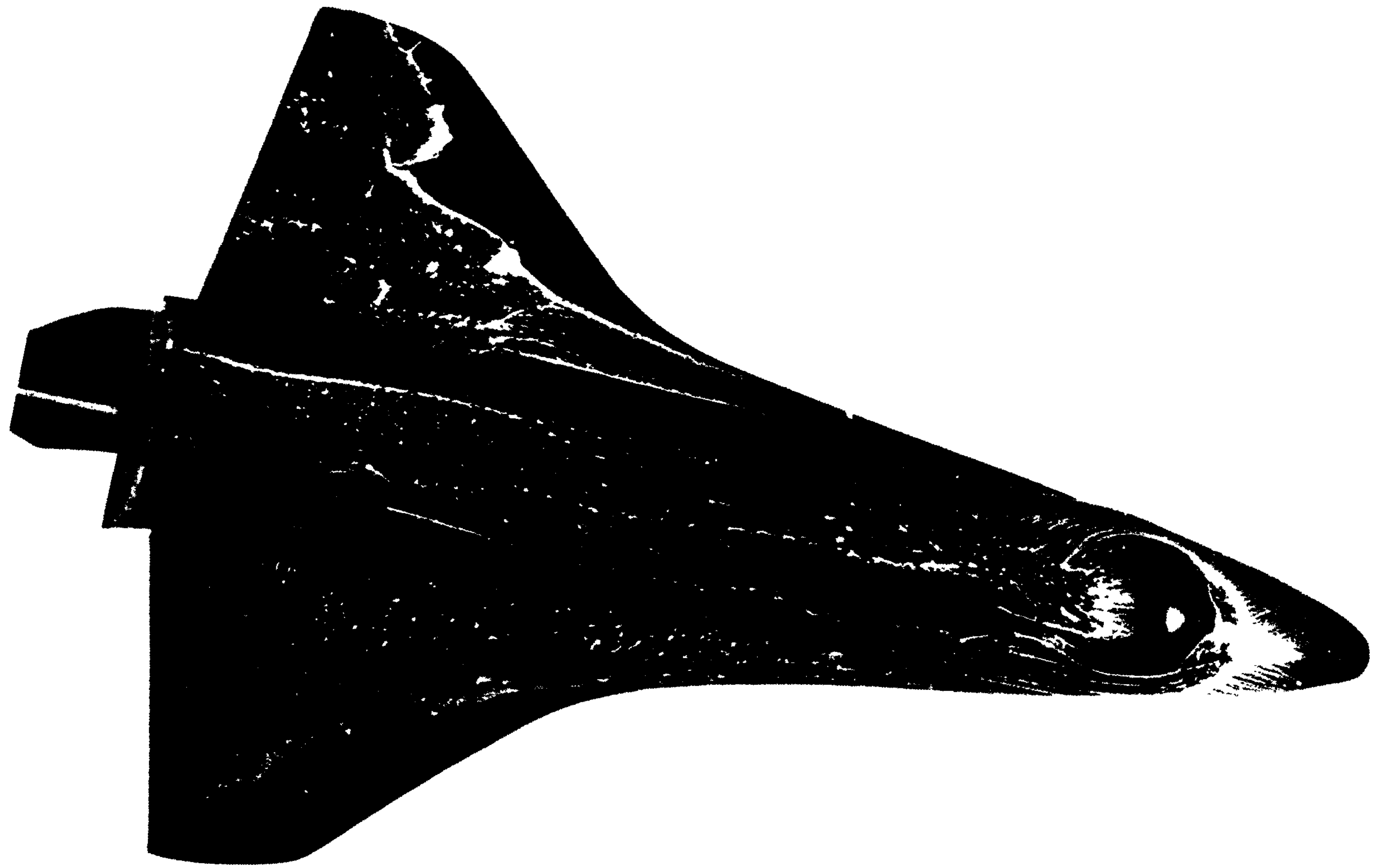


FIGURE 4. (CONTINUED)

C. TOP VIEW

FIGURE 4. (CONTINUED)

D. RIGHT WING-BODY JUNCTION VIEW

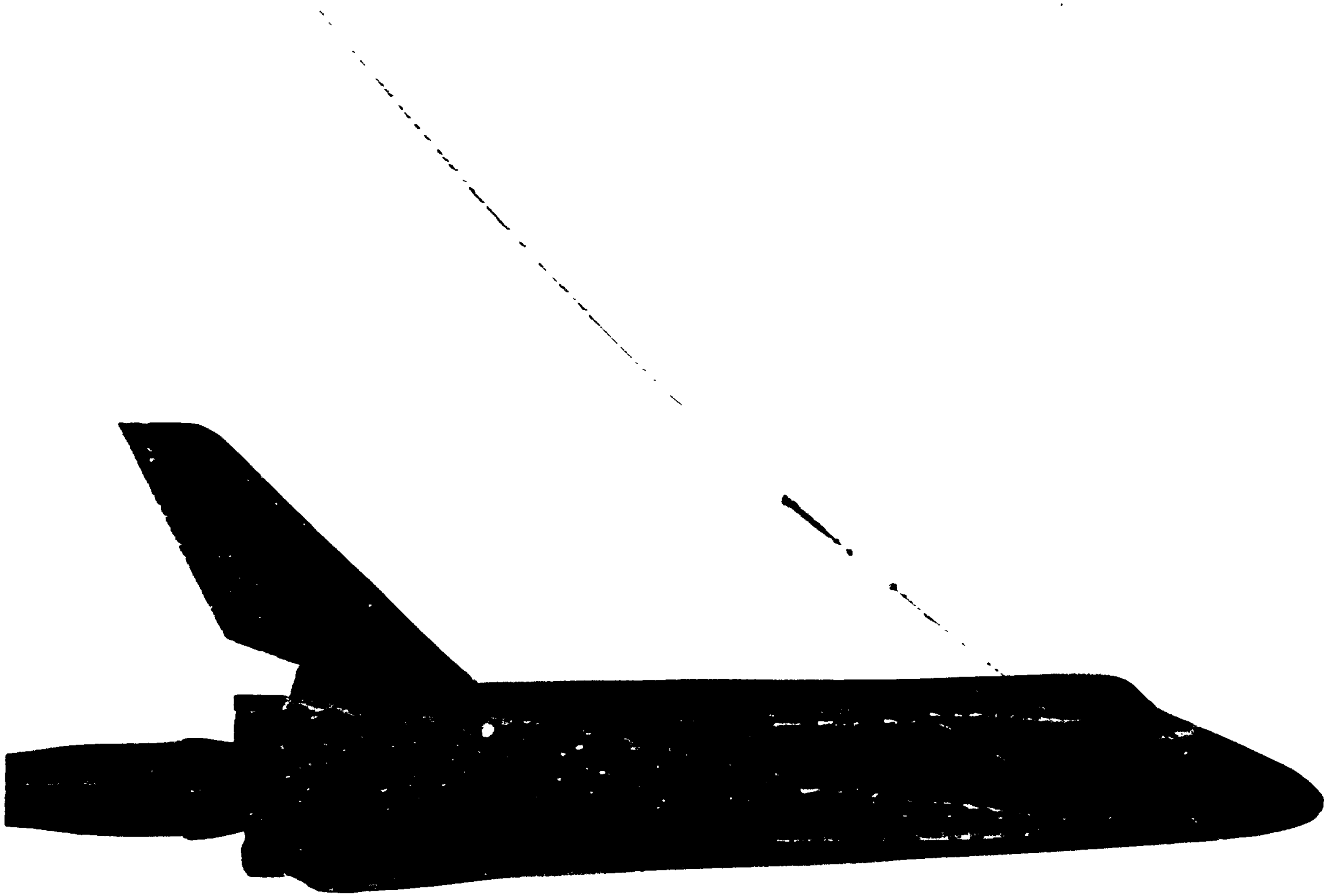


FIGURE 4. (CONTINUED)

E. RIGHT SIDE VIEW

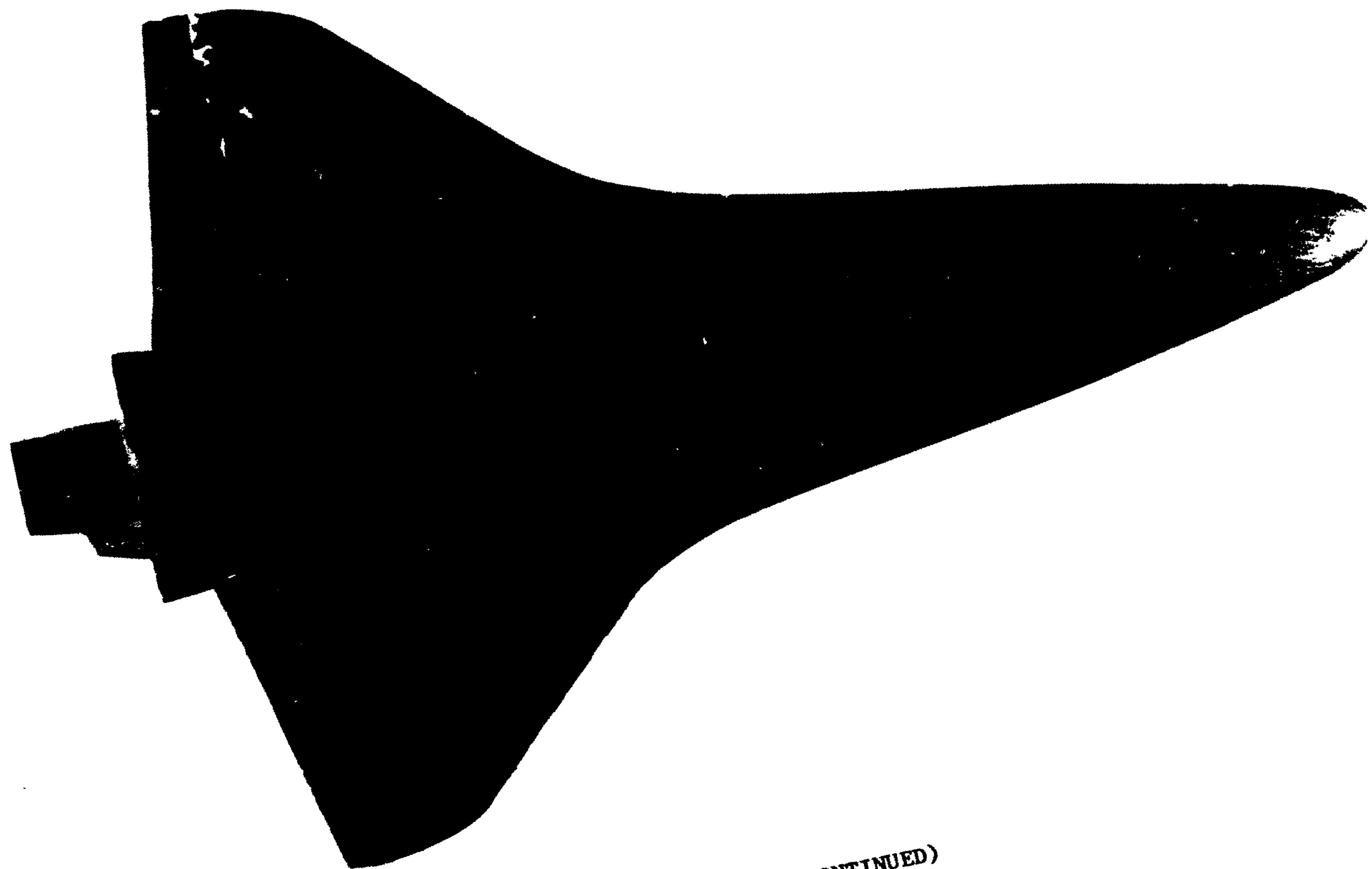


FIGURE 4. (CONTINUED)

F. BOTTOM VIEW

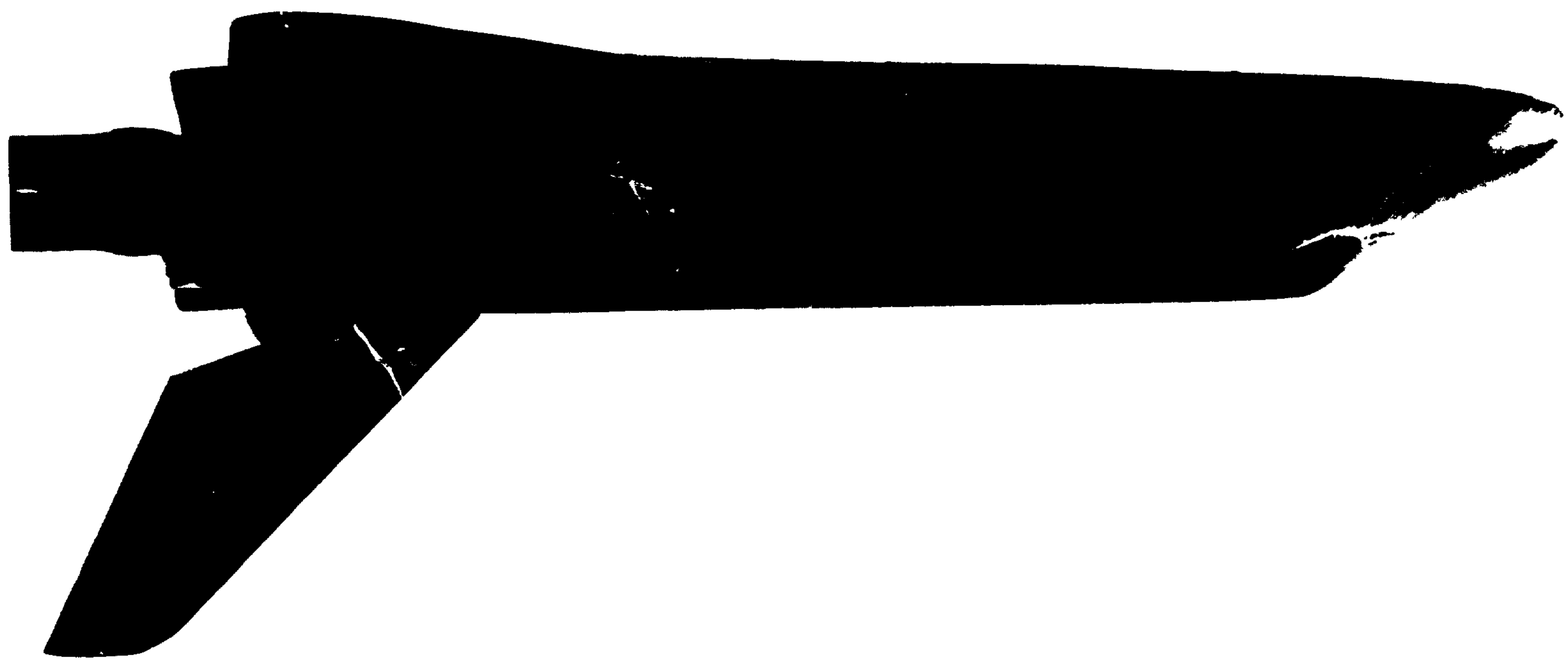


FIGURE 5. OIL FLOW PATTERNS ON THE .01 SCALE MODIFIED ROCKWELL (089B) ORBITER CONFIGURATION AT $\alpha = 20°$, $\beta = -5°$, $\delta_{e_L} = -10°$, $\delta_{eR} = 0°$, $RN/L = 9.4 \times 10^6$, ROUGHNESS ON

A. LEFT SIDE VIEW

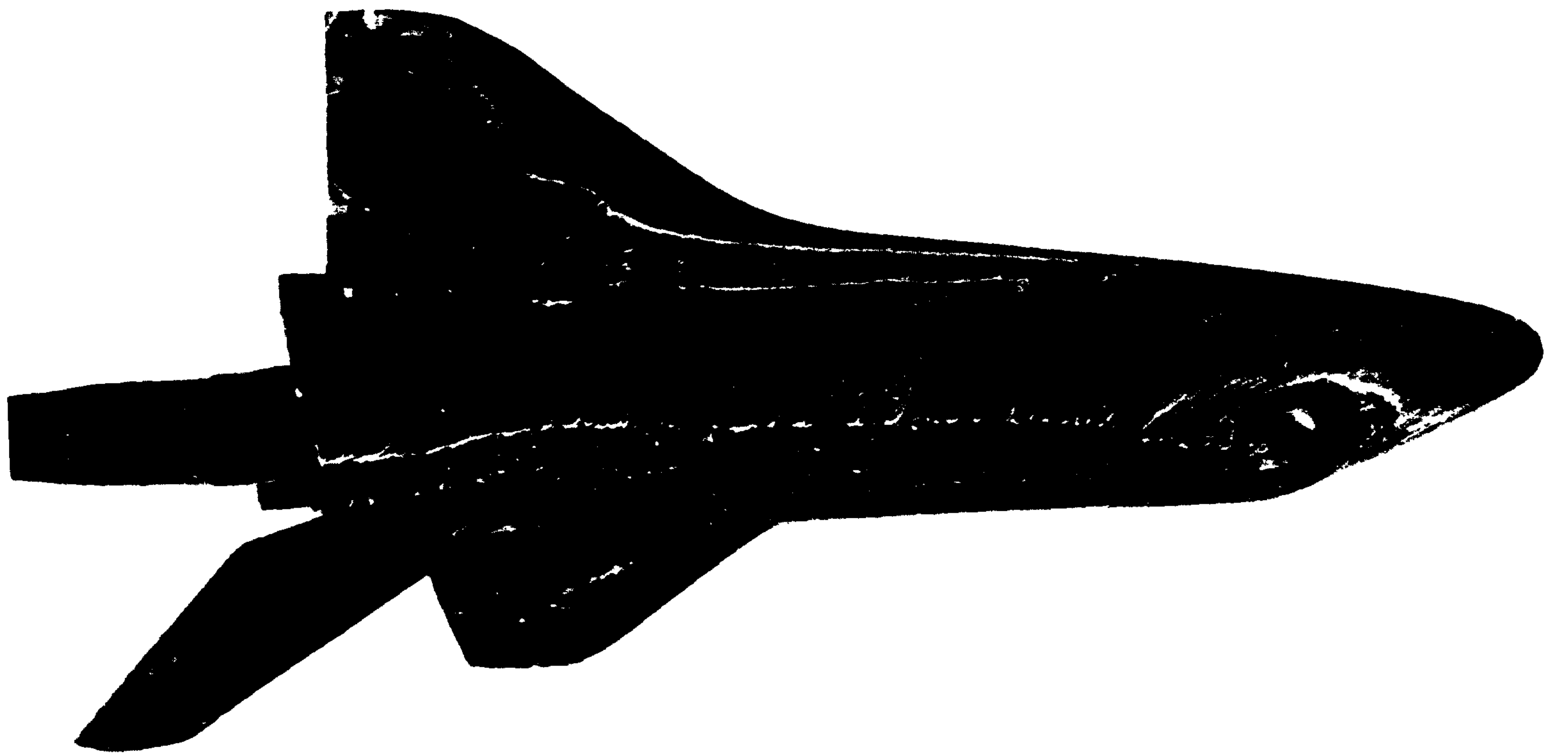


FIGURE 5. (CONTINUED)

B. LEFT WING-BODY JUNCTION VIEW

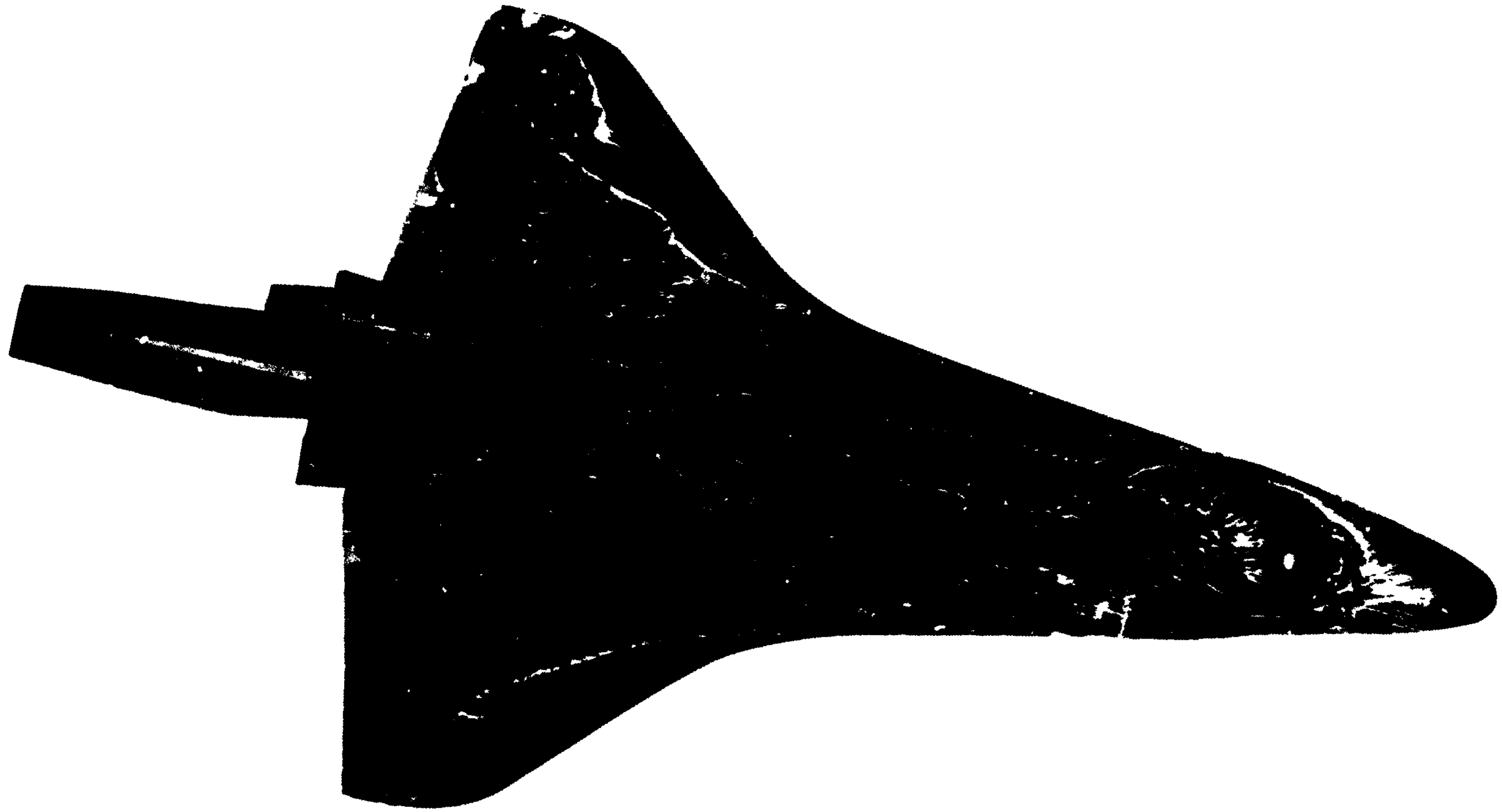


FIGURE 5. (CONTINUED)

C. TOP VIEW

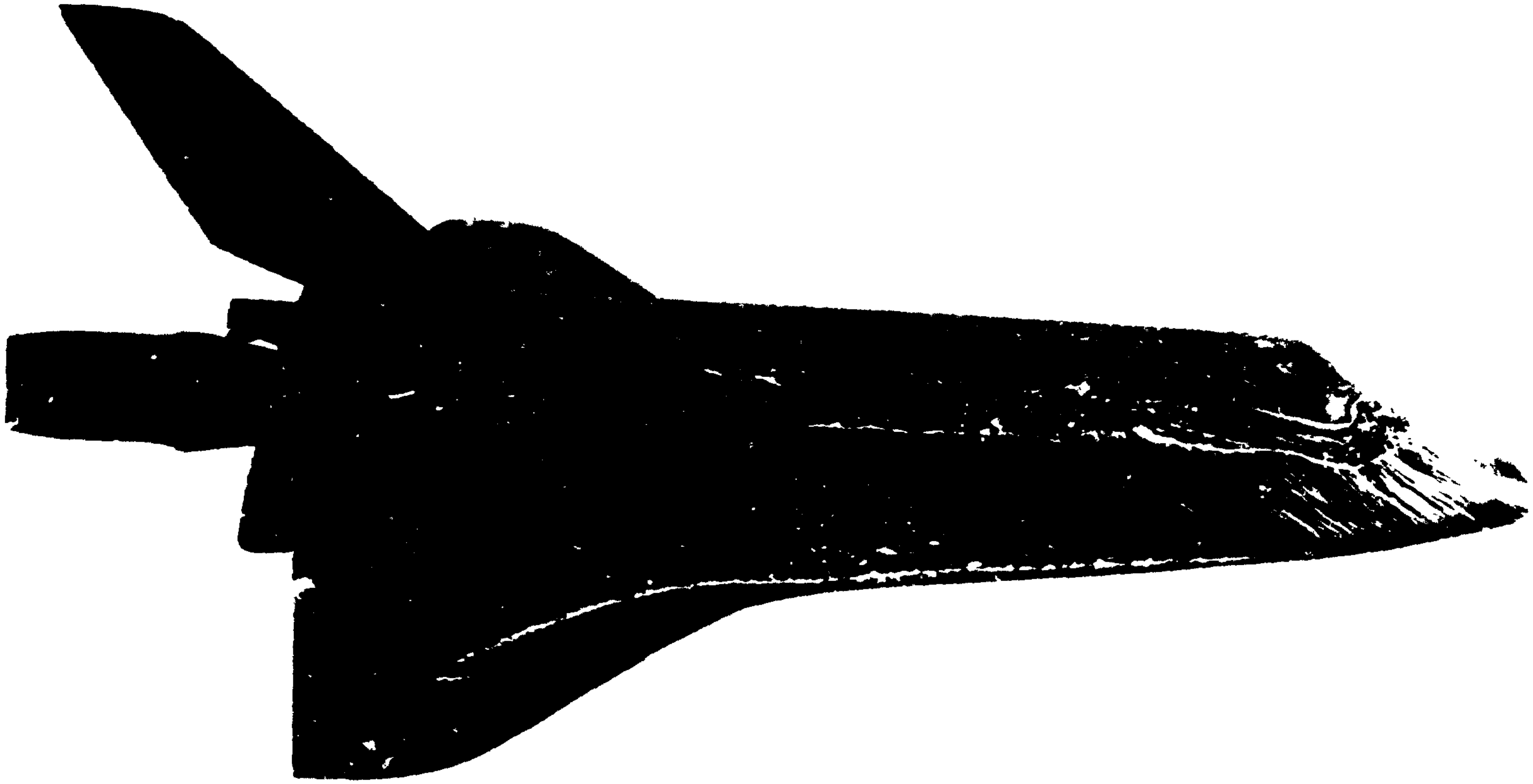


FIGURE 5. (CONTINUED)

D. RIGHT WING-BODY JUNCTION VIEW

TABLE 5. (CONTINUED)

E. RIGHT SIDE VIEW

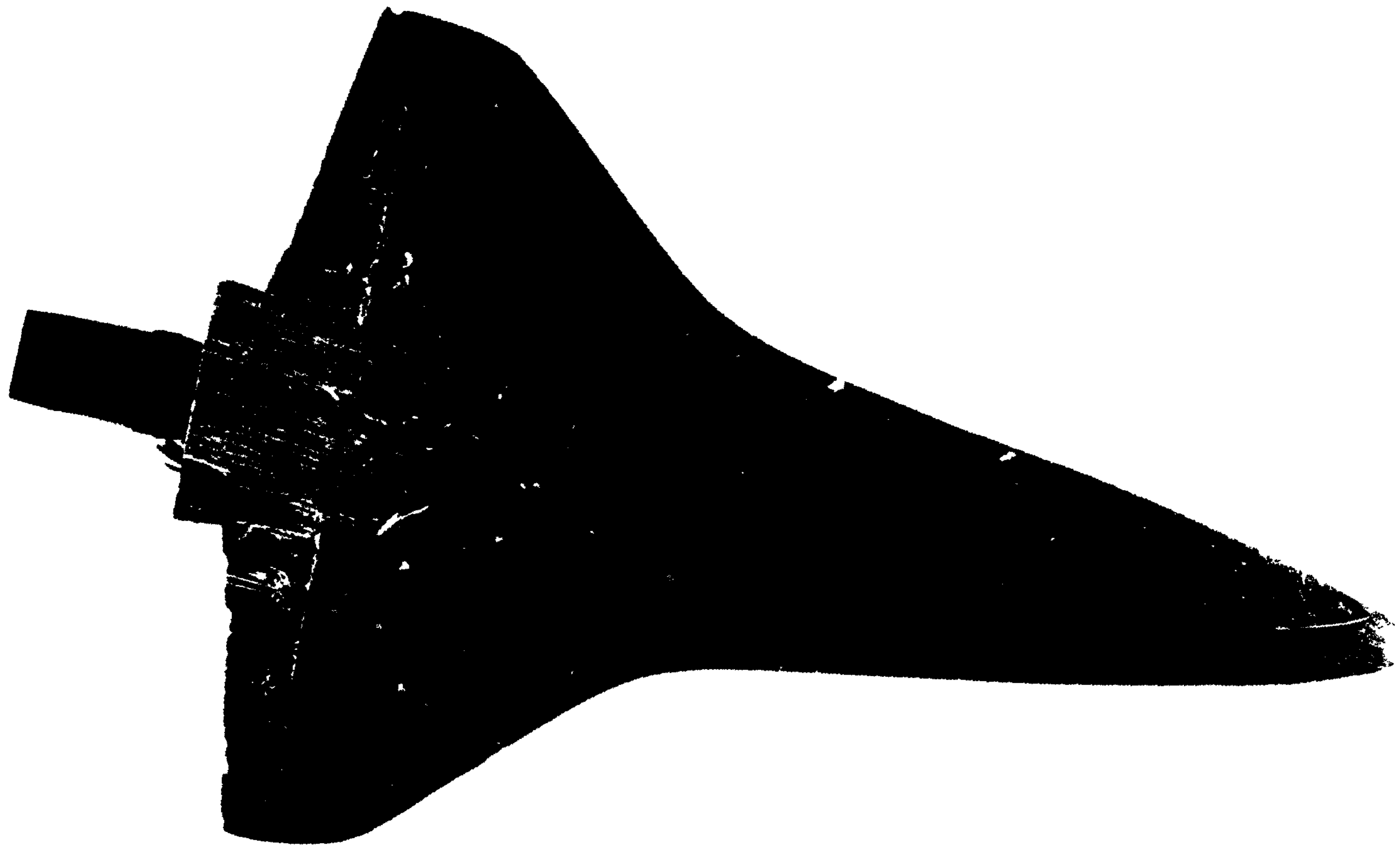


FIGURE 5. (CONTINUED)

F. BOTTOM VIEW

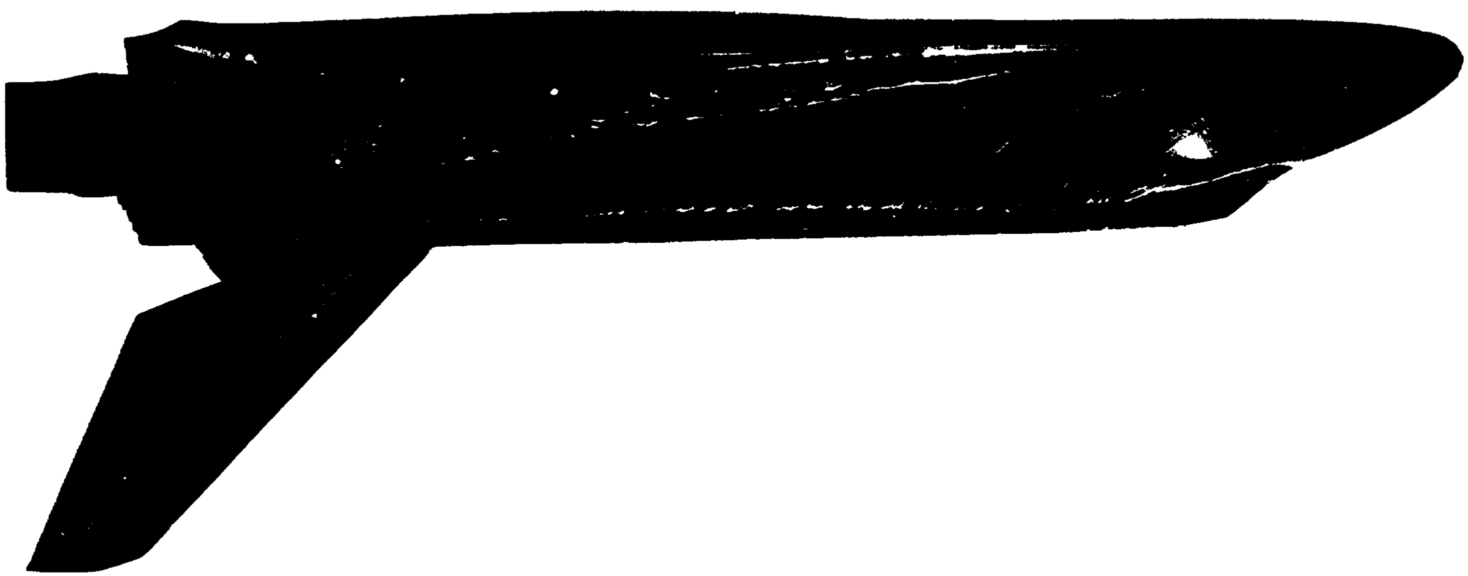


FIGURE 6. OIL FLOW PATTERNS ON THE .01 SCALE MODIFIED ROCKWELL (089B) ORBITER CONFIGURATION AT $\alpha = 20°$, $\beta = 0°$, $\delta_{e_L} = 14°$, $\delta_{eR} = 6°$, RN/L = 9.4×10^6, ROUGHNESS OFF

A. LEFT SIDE VIEW

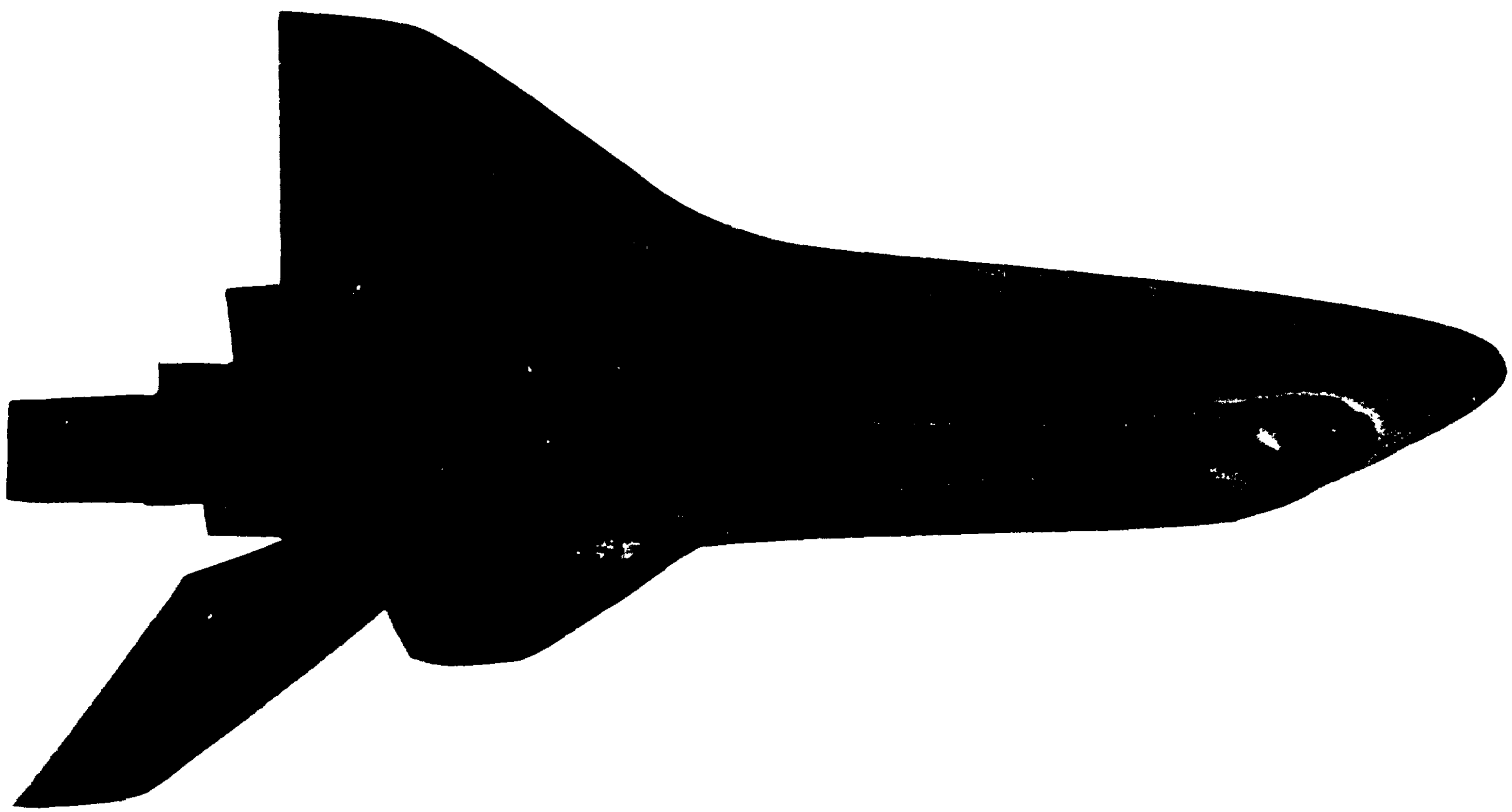


FIGURE 6. (CONTINUED)

B. LEFT WING-BODY JUNCTION VIEW

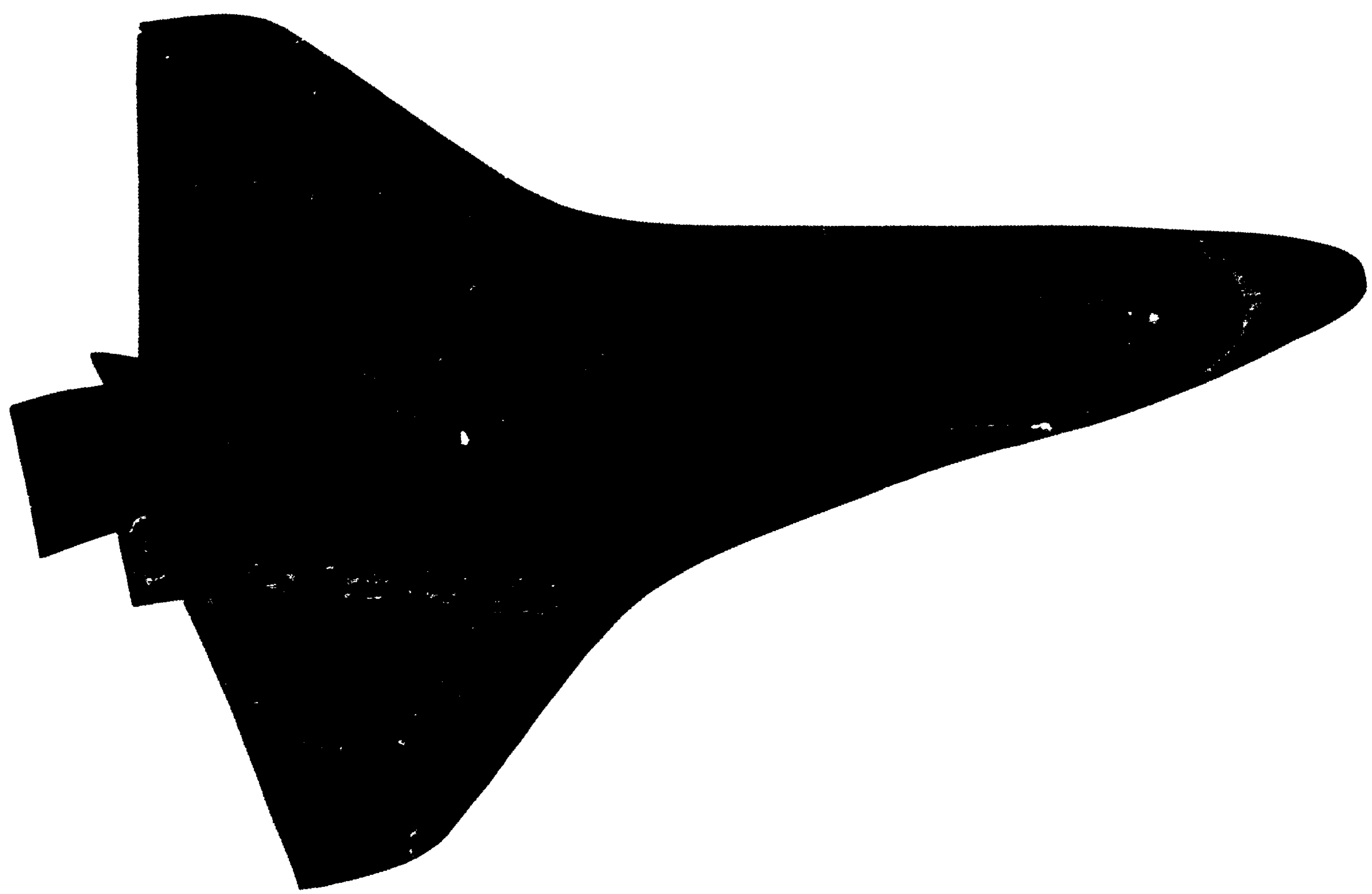


FIGURE 6. (CONTINUED)

C. TOP VIEW

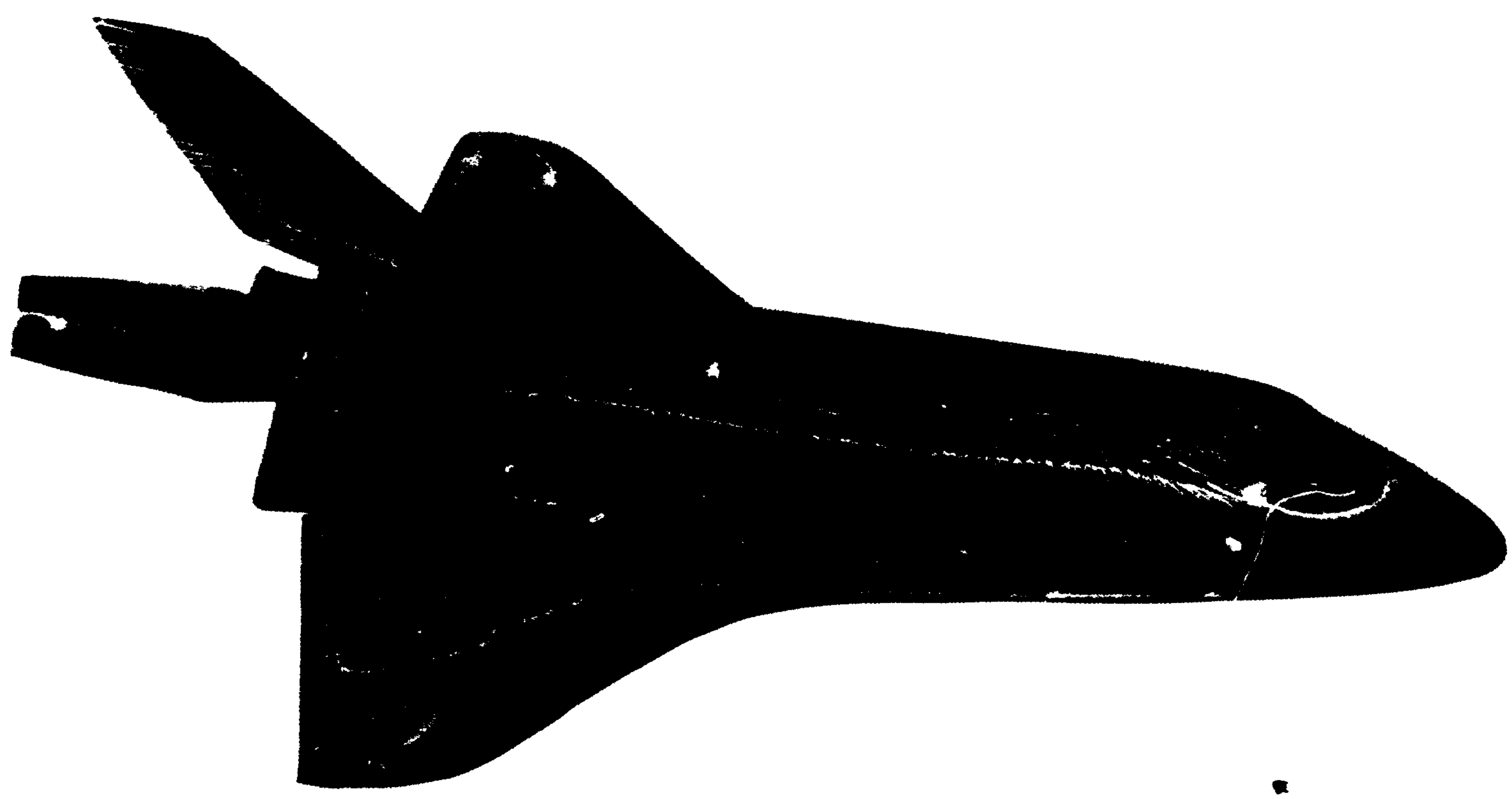


FIGURE 6. (CONTINUED)

D. RIGHT WING-BODY JUNCTION VIEW

FIGURE 6. (CONTINUED)

E. RIGHT SIDE VIEW

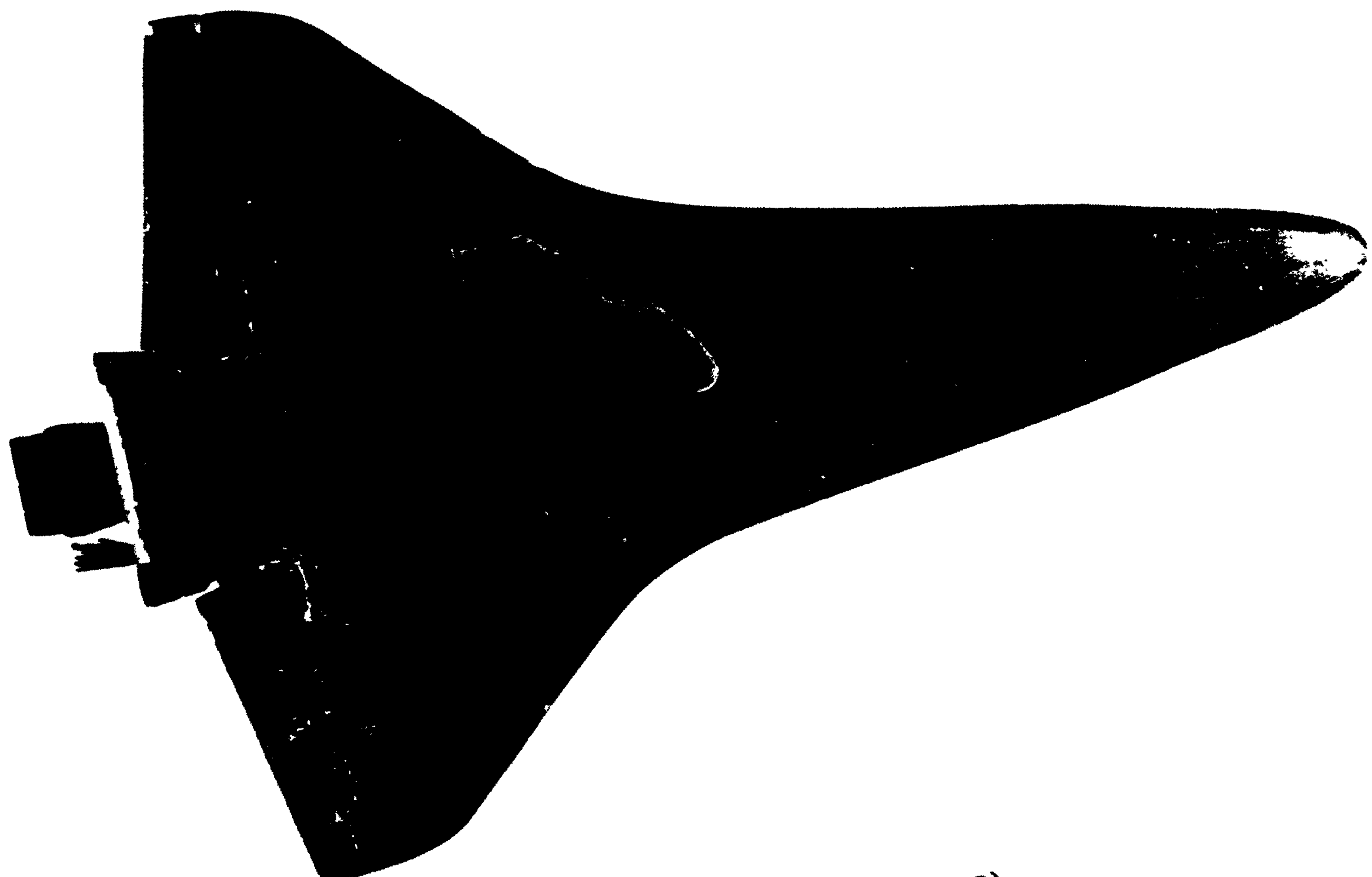


FIGURE 6. (CONTINUED)

F. BOTTOM VIEW

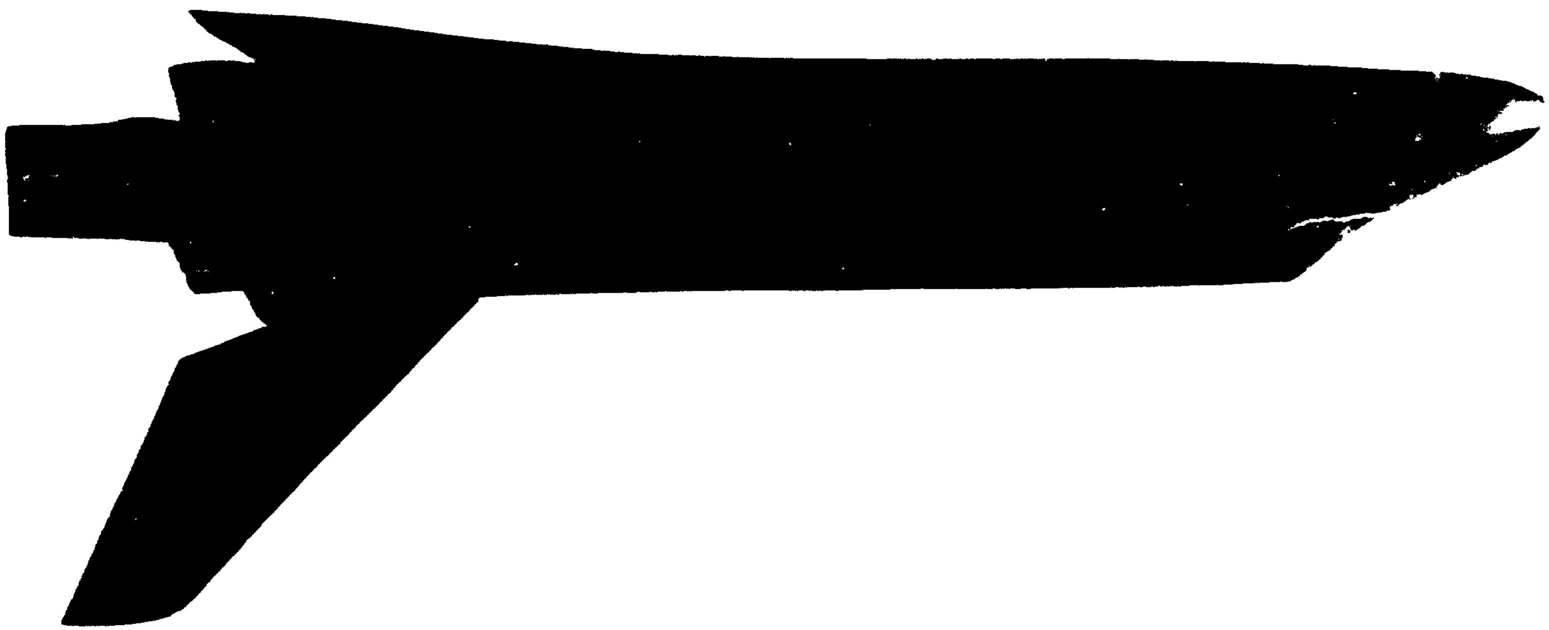


FIGURE 7. OIL FLOW PATTERNS ON THE .01 SCALE MODIFIED ROCKWELL (089B) ORBITER CONFIGURATION AT α = 20°, β = -5°, δ_{eL} = 14°, δ_{eR} = 6°, RN/L = 9.4 x 10^6, ROUGHNESS OFF

A. LEFT SIDE VIEW

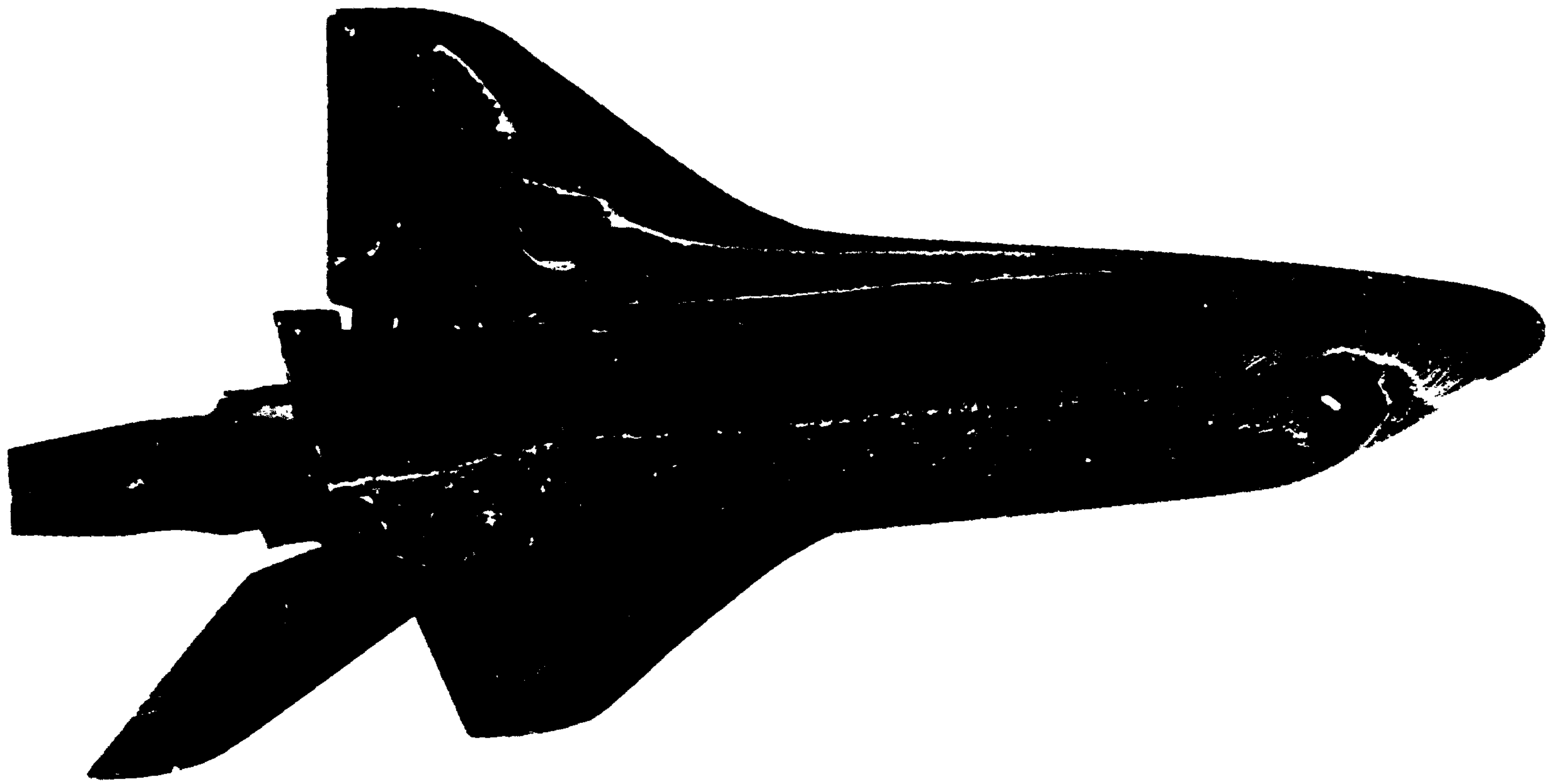


FIGURE 7. (CONTINUED)

B. LEFT WING-BODY JUNCTION VIEW

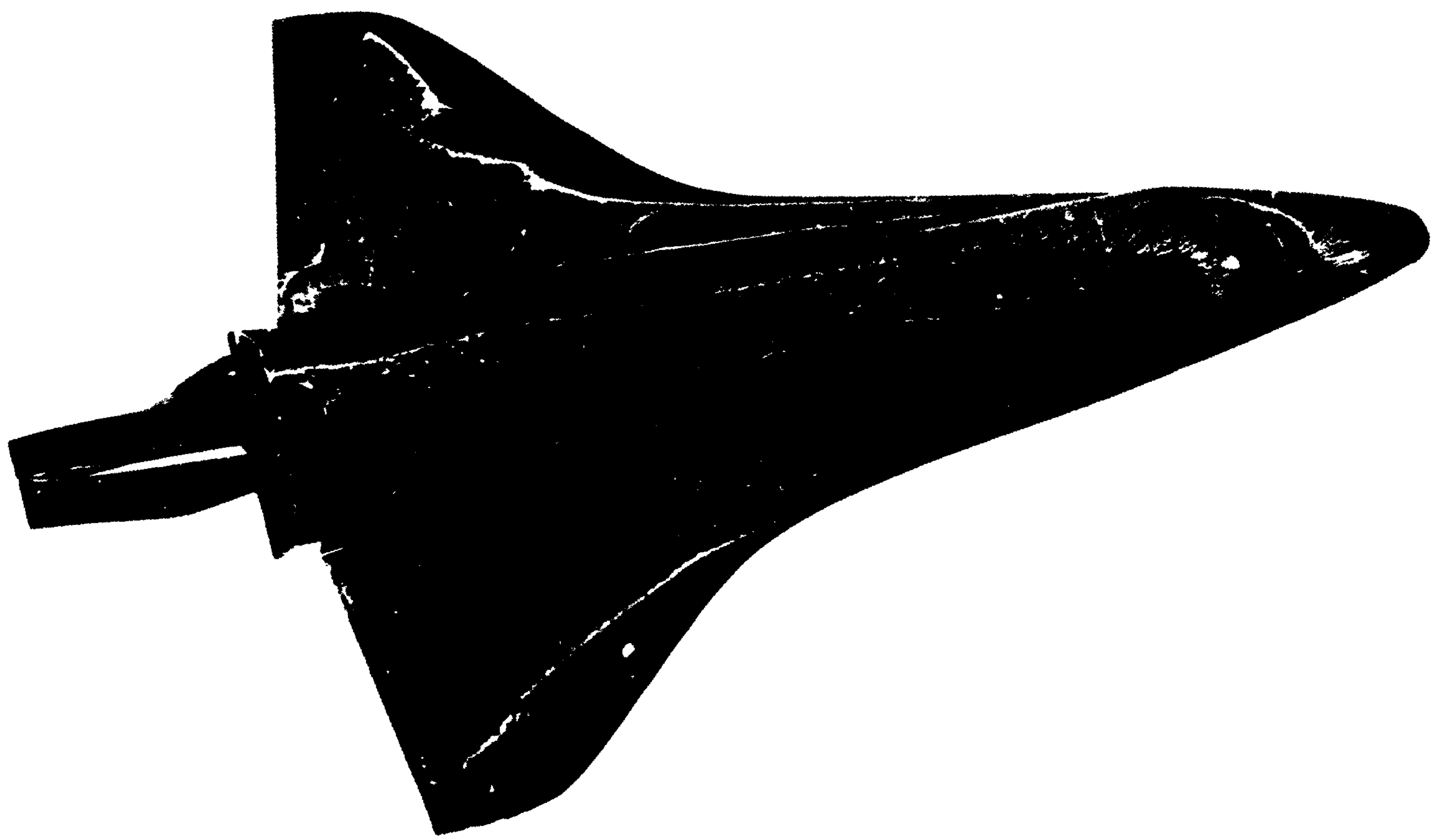


FIGURE 7. (CONTINUED)

C. TOP VIEW

FIGURE 7. (CONTINUED)

D. RIGHT WING-BODY JUNCTION VIEW

FIGURE 7. (CONTINUED)

E. RIGHT SIDE VIEW

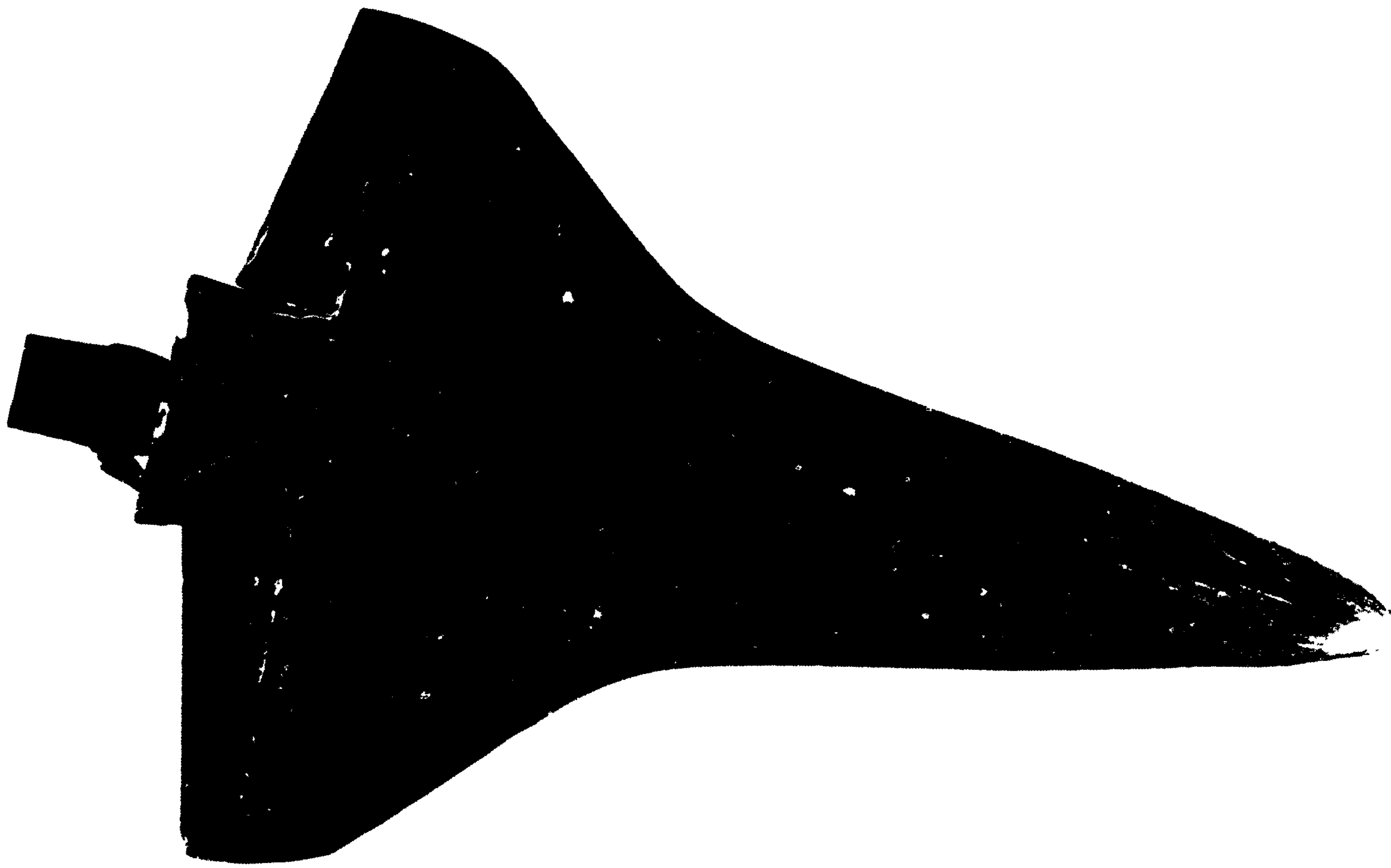


FIGURE 7. (CONTINUED)

F. BOTTOM VIEW

FIGURE 8. OIL FLOW PATTERNS ON THE .01 SCALE MODIFIED ROCKWELL (089B) ORBITER CONFIGURATION AT $\alpha = 20°$, $\beta = 0°$, $\delta_{eL} = \delta_{eR} = -30°$, $RN/L = 9.4 \times 10^6$, ROUGHNESS OFF

A. LEFT SIDE VIEW

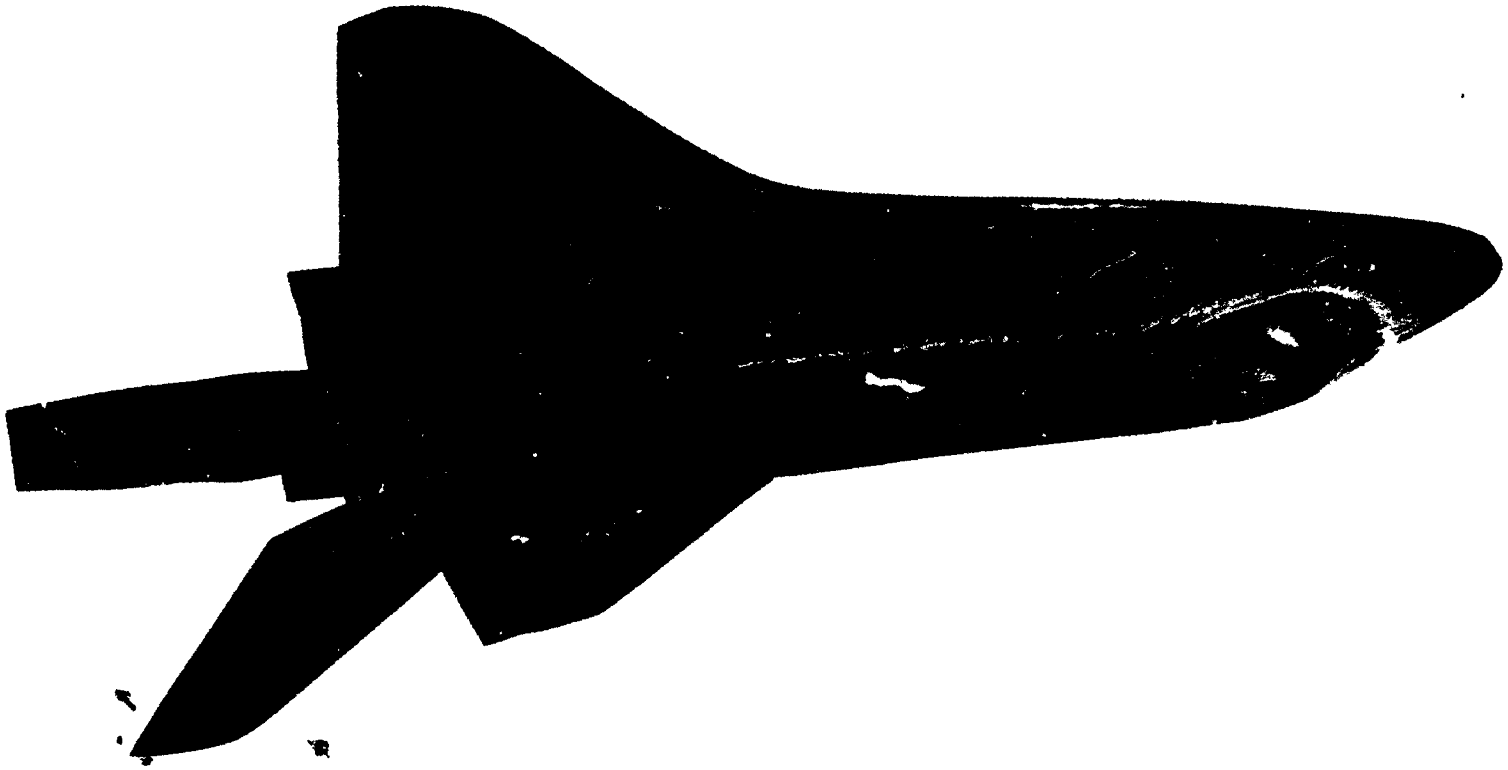


FIGURE 8. (CONTINUED)

B. LEFT WING-BODY JUNCTION VIEW

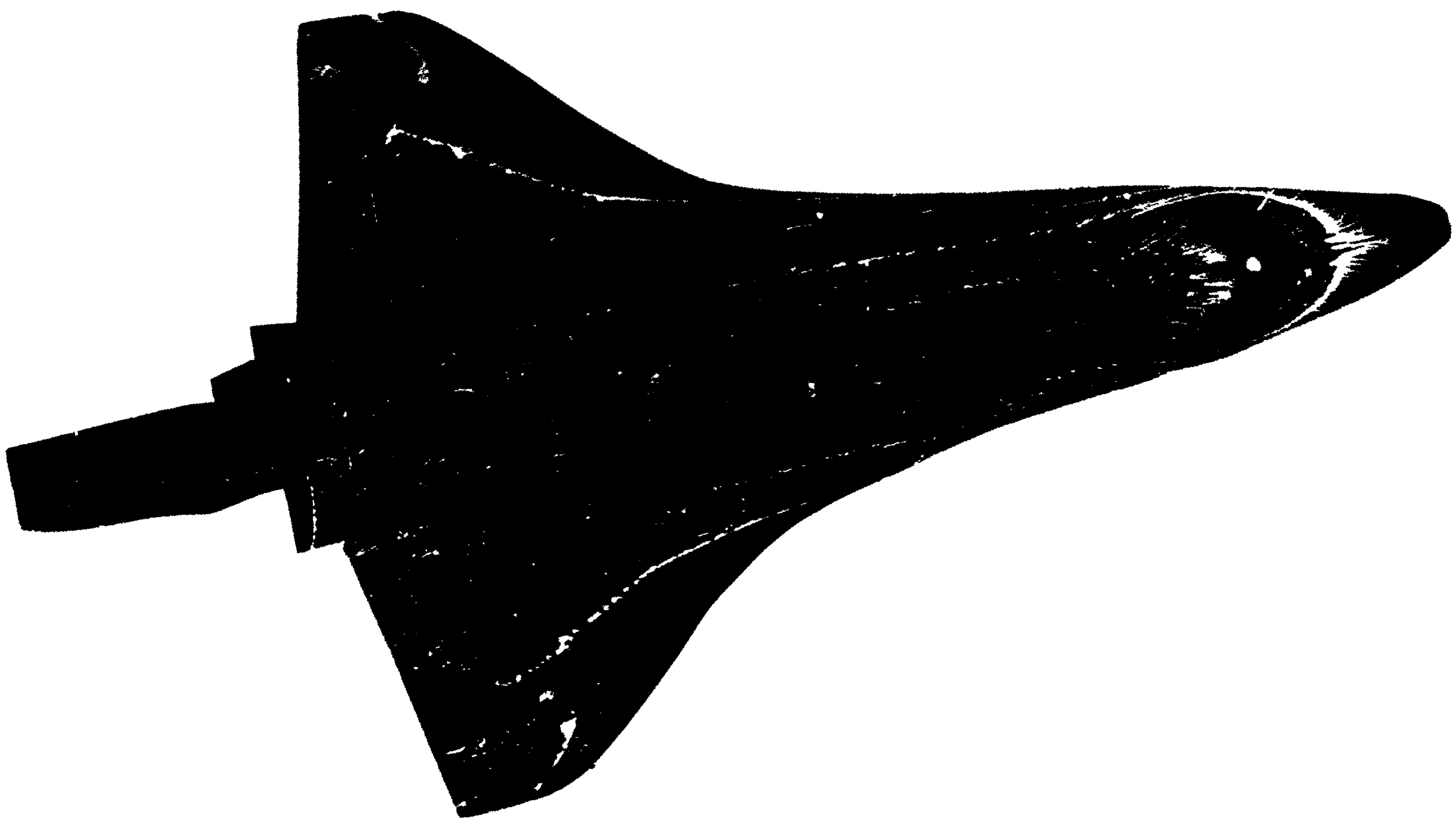


FIGURE 8. (CONTINUED)

C. TOP VIEW

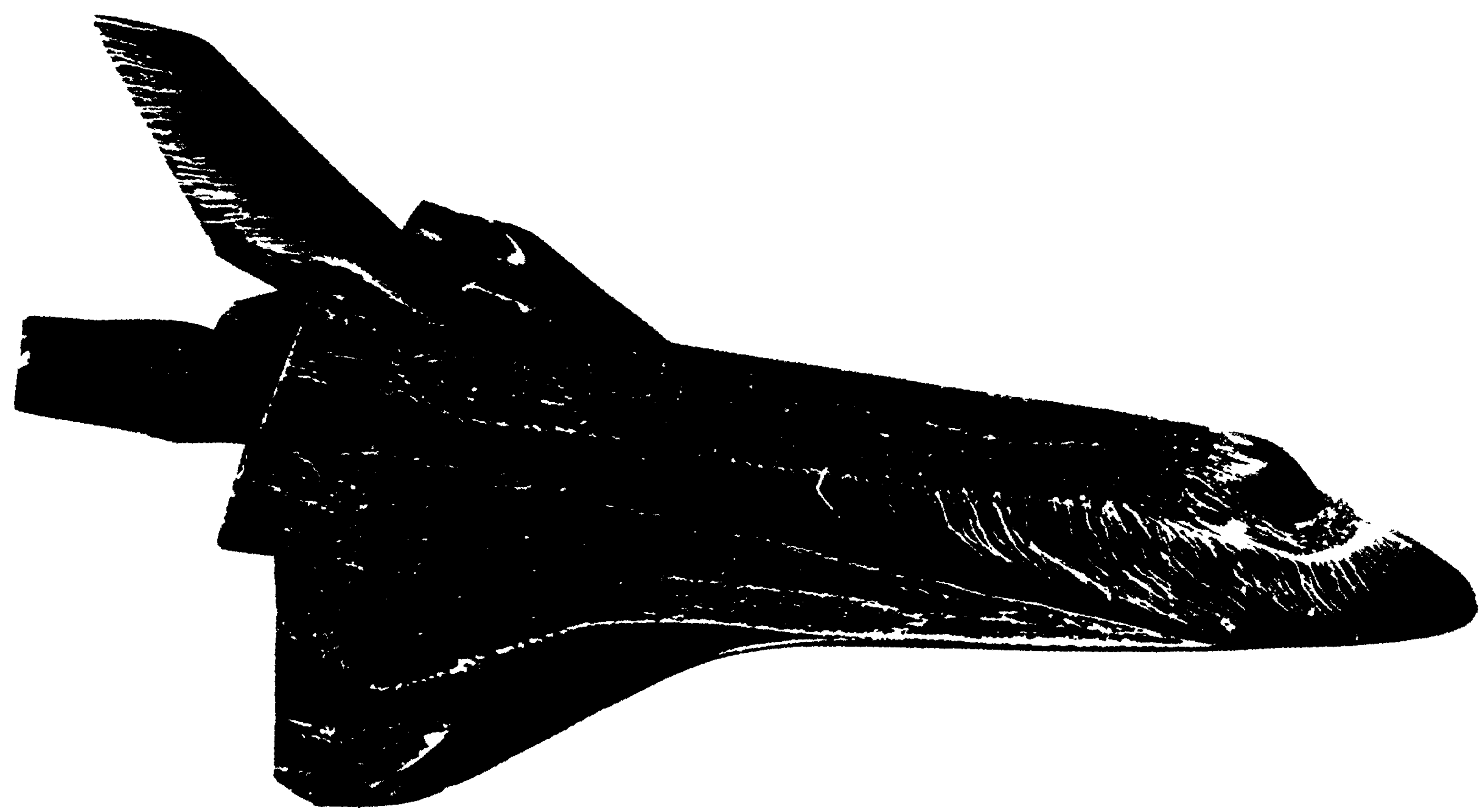


FIGURE 8. (CONTINUED)

D. RIGHT WING-BODY JUNCTION VIEW

FIGURE 8. (CONTINUED)

E. RIGHT SIDE VIEW

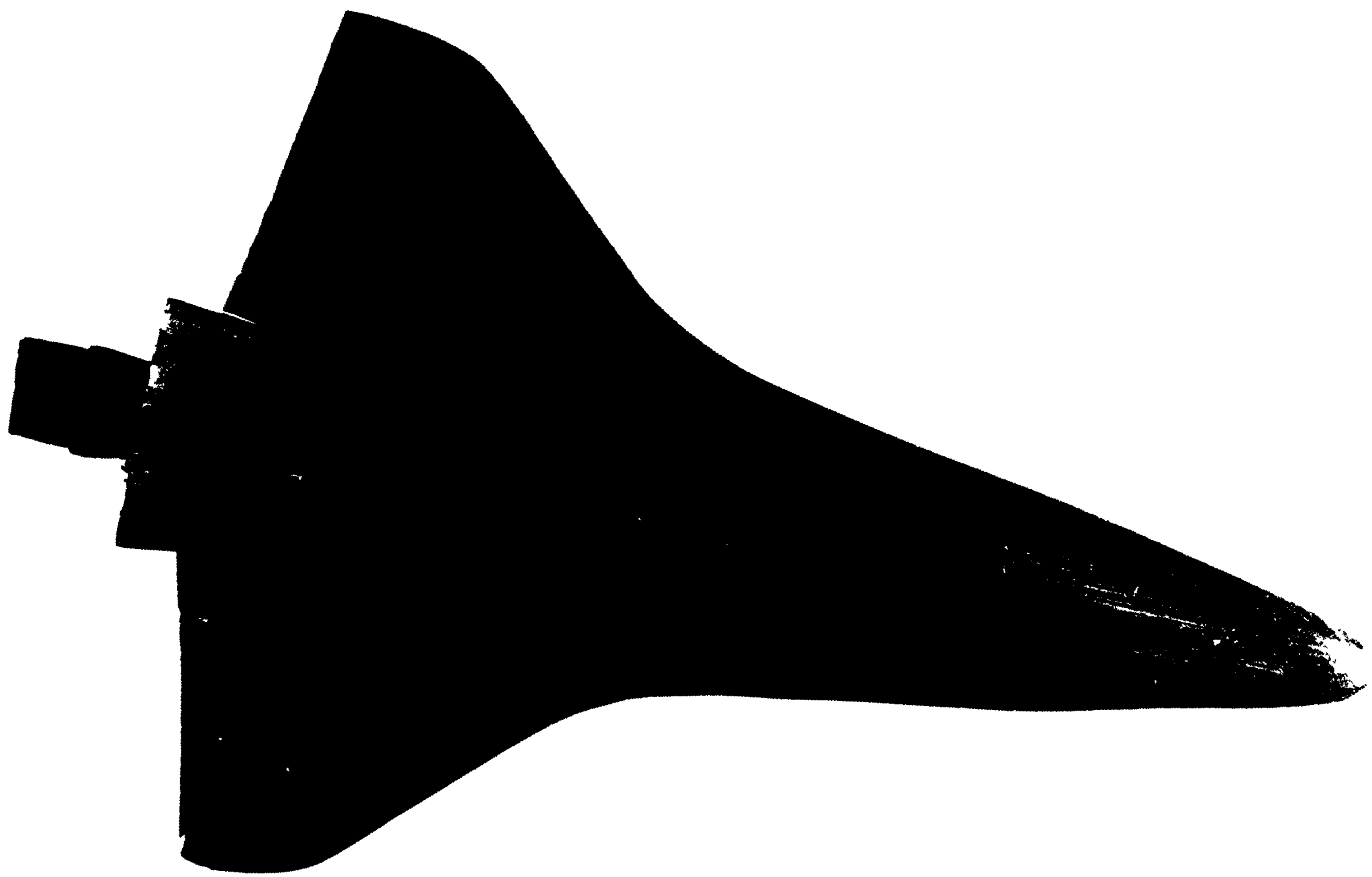


FIGURE 8. (CONTINUED)

F. BOTTOM VIEW

FIGURE 9. OIL FLOW PATTERNS ON THE .01 SCALE MODIFIED ROCKWELL (089B) ORBITER CONFIGURATION AT $\alpha = 20°$ $\beta = 0°$, $\delta_{eL} = -10°$, $\delta_{eR} = 0°$, RN/L = 4.0×10^6, ROUGHNESS OFF

A. LEFT SIDE VIEW

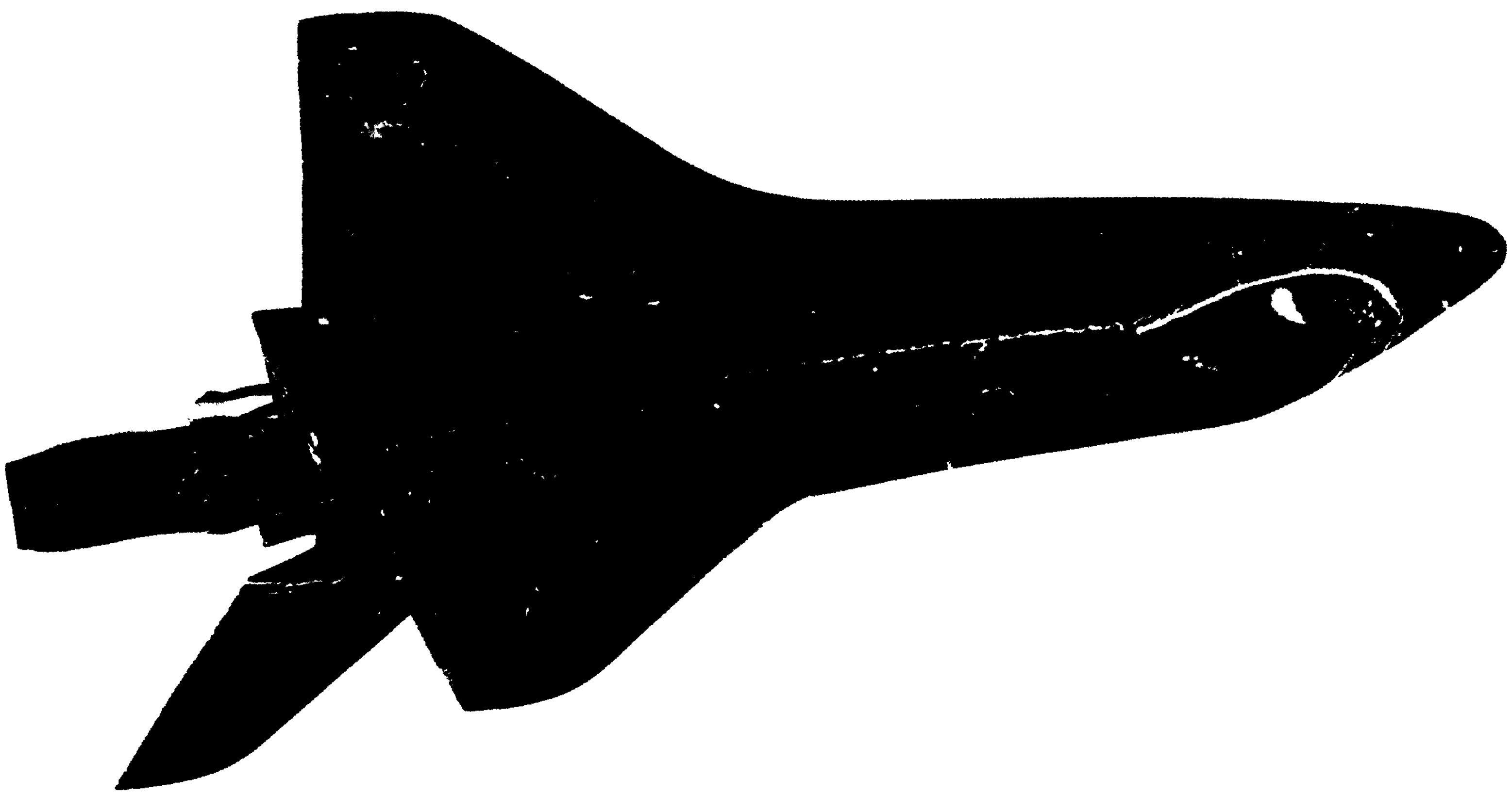


FIGURE 9. (CONTINUED)

B. LEFT WING-BODY JUNCTION VIEW

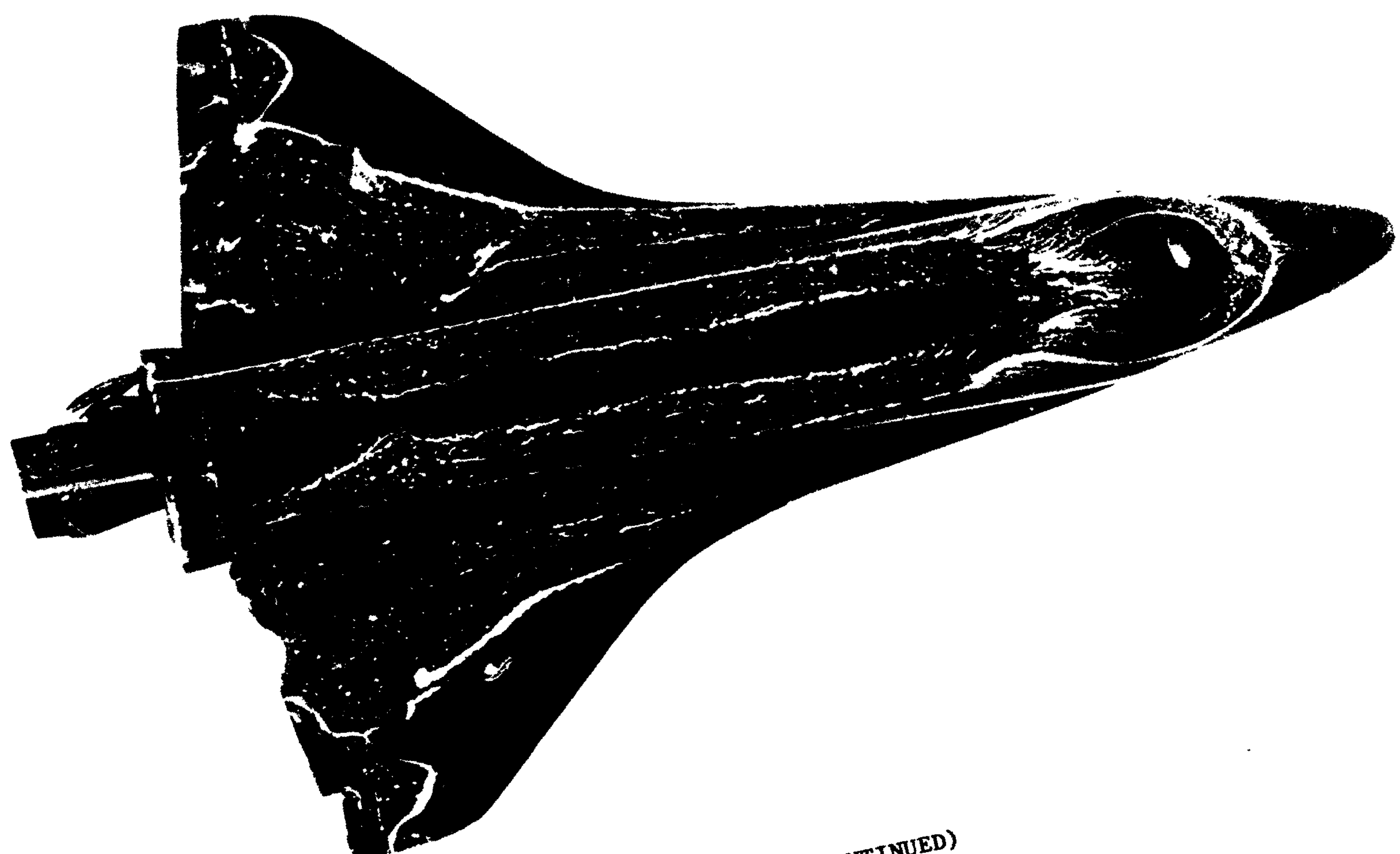


FIGURE 9. (CONTINUED)

C. TOP VIEW

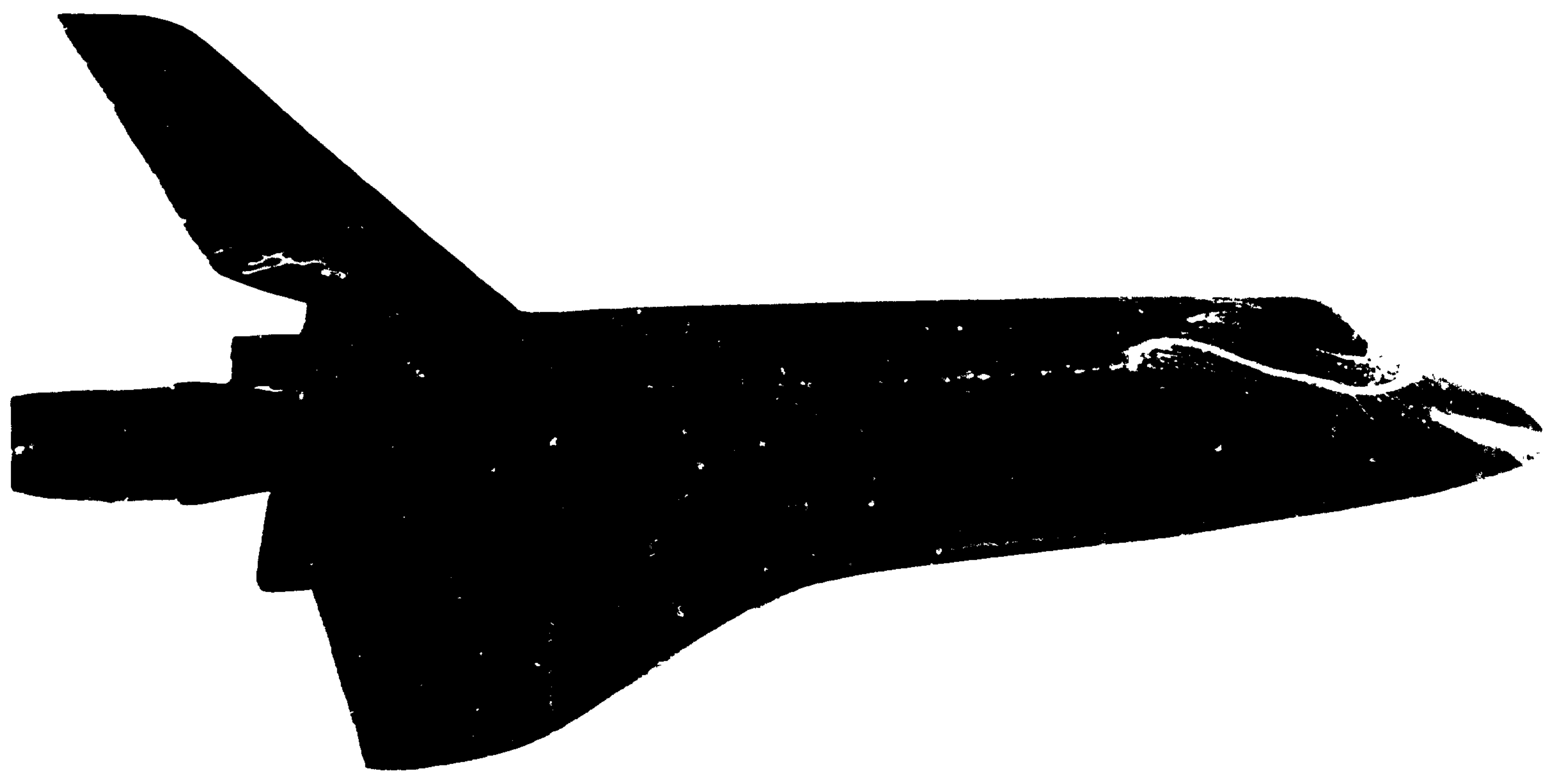


FIGURE 9. (CONTINUED)

D. RIGHT WING-BODY JUNCTION VIEW

FIGURE 9. (CONTINUED)

E. RIGHT SIDE VIEW

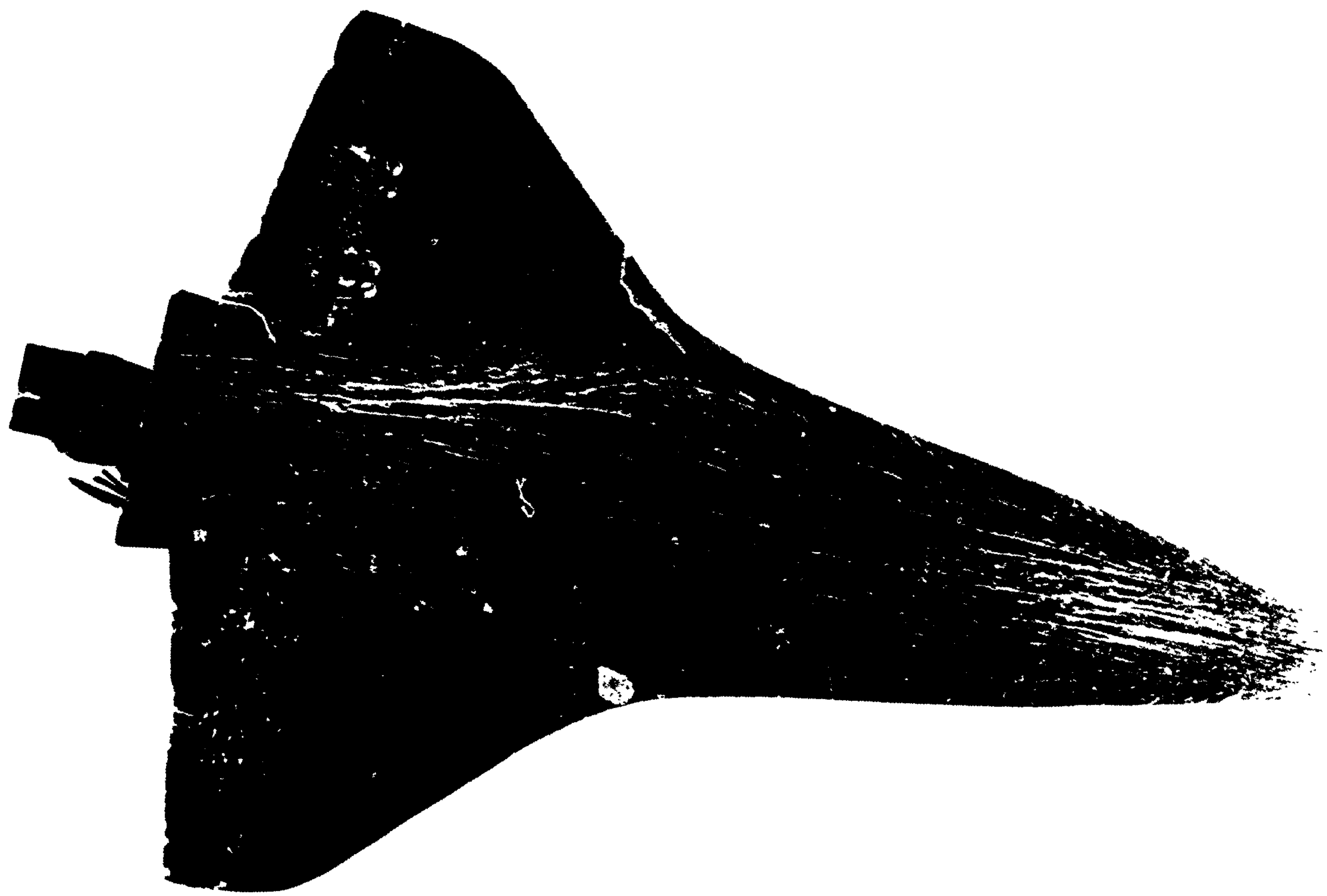


FIGURE 9. (CONTINUED)

F. BOTTOM VIEW

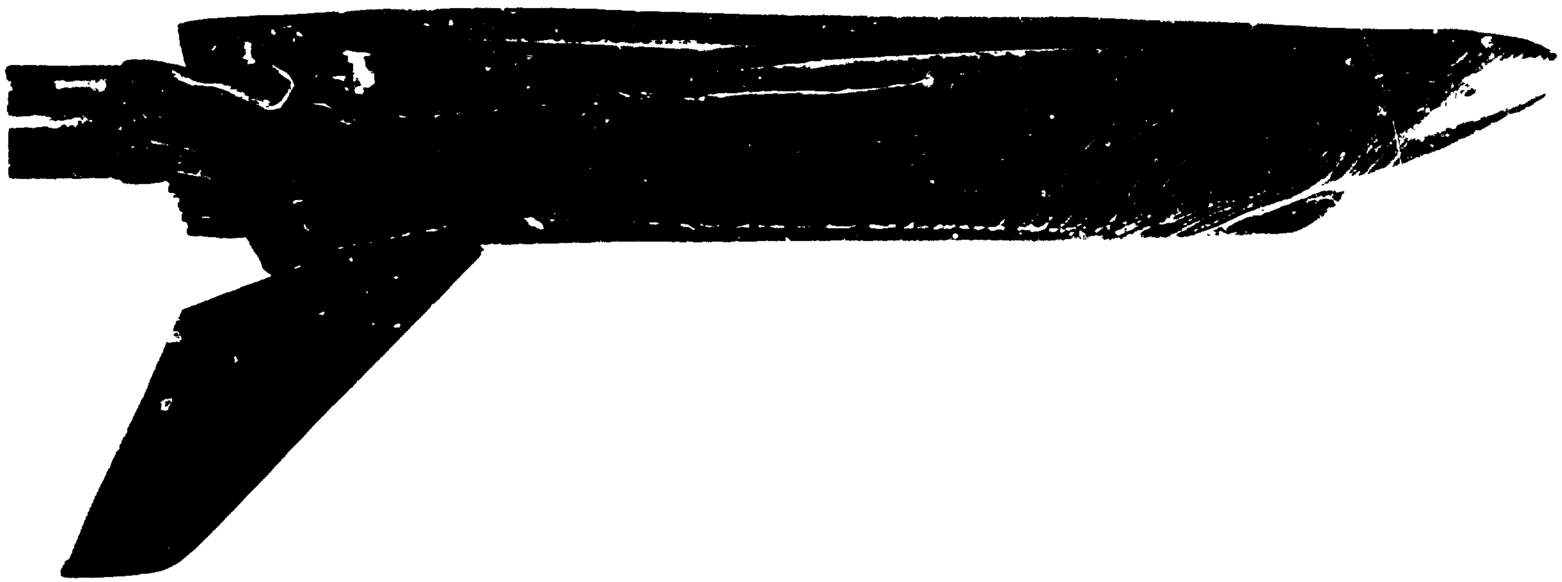


FIGURE 10. OIL FLOW PATTERNS ON THE .01 SCALE MODIFIED ROCKWELL (089B) ORBITER CONFIGURATION AT α = 20° β = -5°, δ_{e_L} = -10°, δ_{e_R} = 0°, RN/L - 4.0 x 10^6, ROUGHNESS OFF

A. LEFT SIDE VIEW

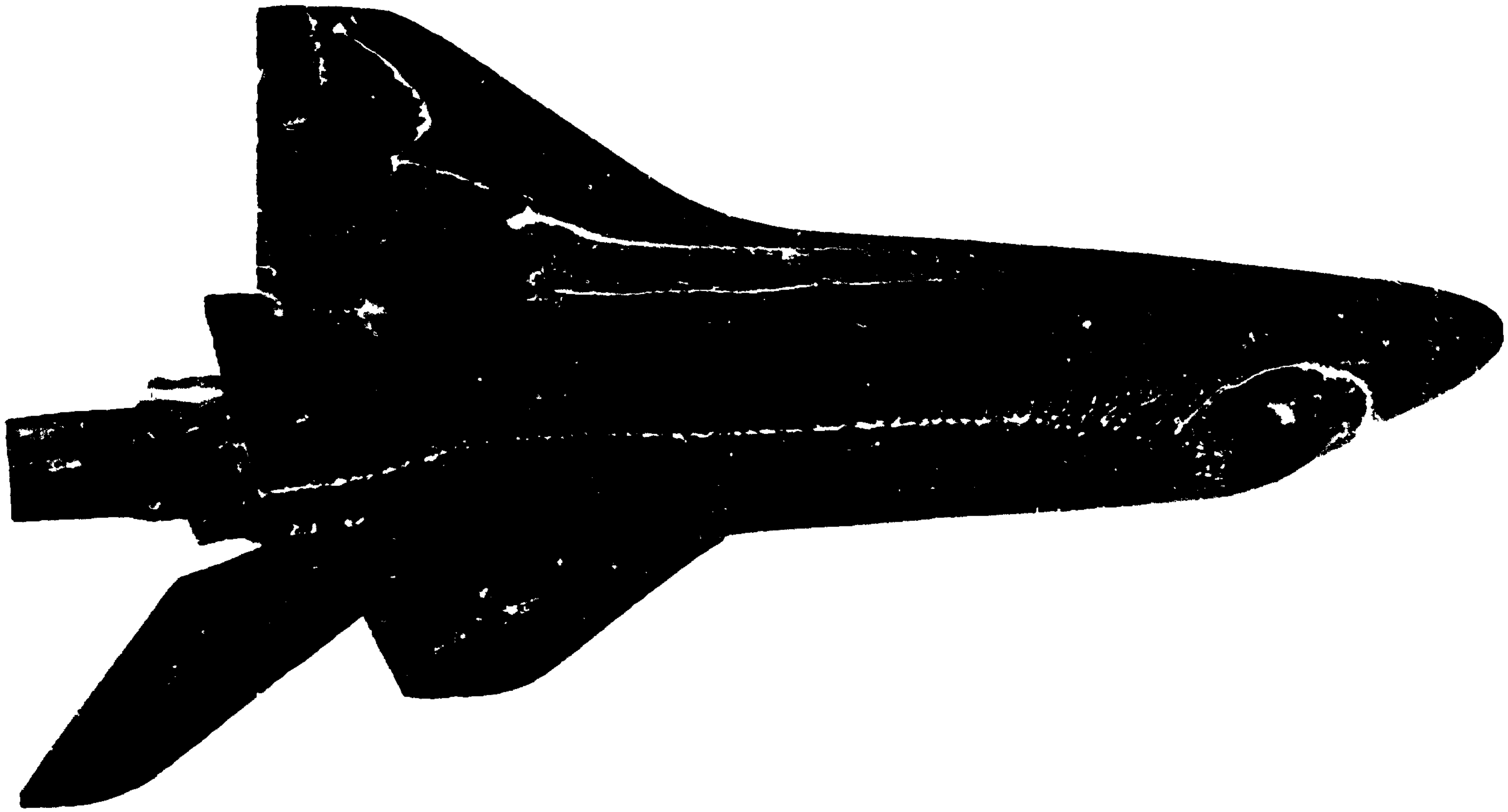


FIGURE 10. (CONTINUED)

B. LEFT WING-BODY JUNCTION VIEW

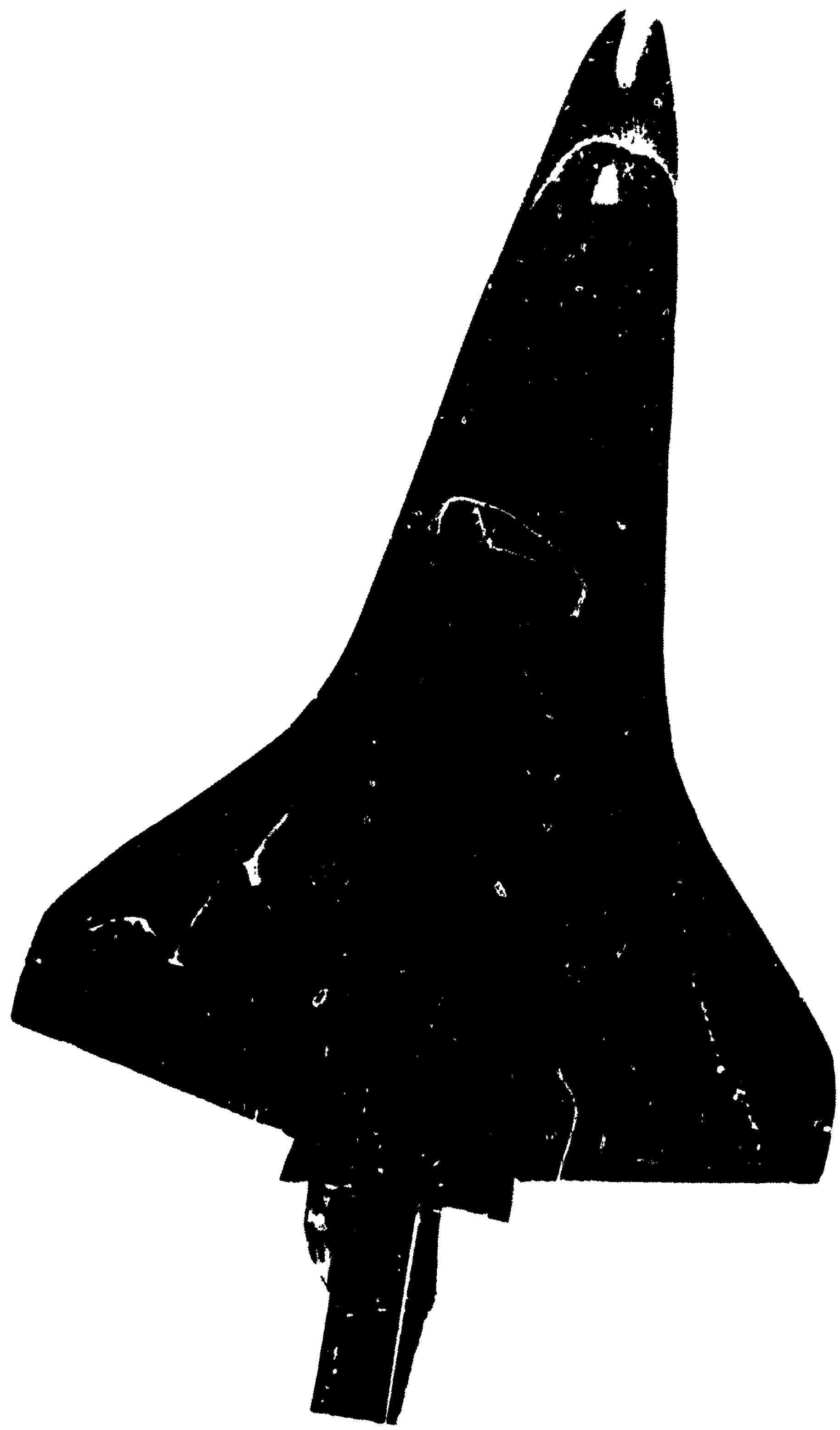


FIGURE 10. (CONTINUED)
C. TOP VIEW

FIGURE 10. (CONTINUED)

D. RIGHT WING-BODY JUNCTION VIEW

FICURE 10. (CONTINUED)

E. RIGHT SIDE VIEW

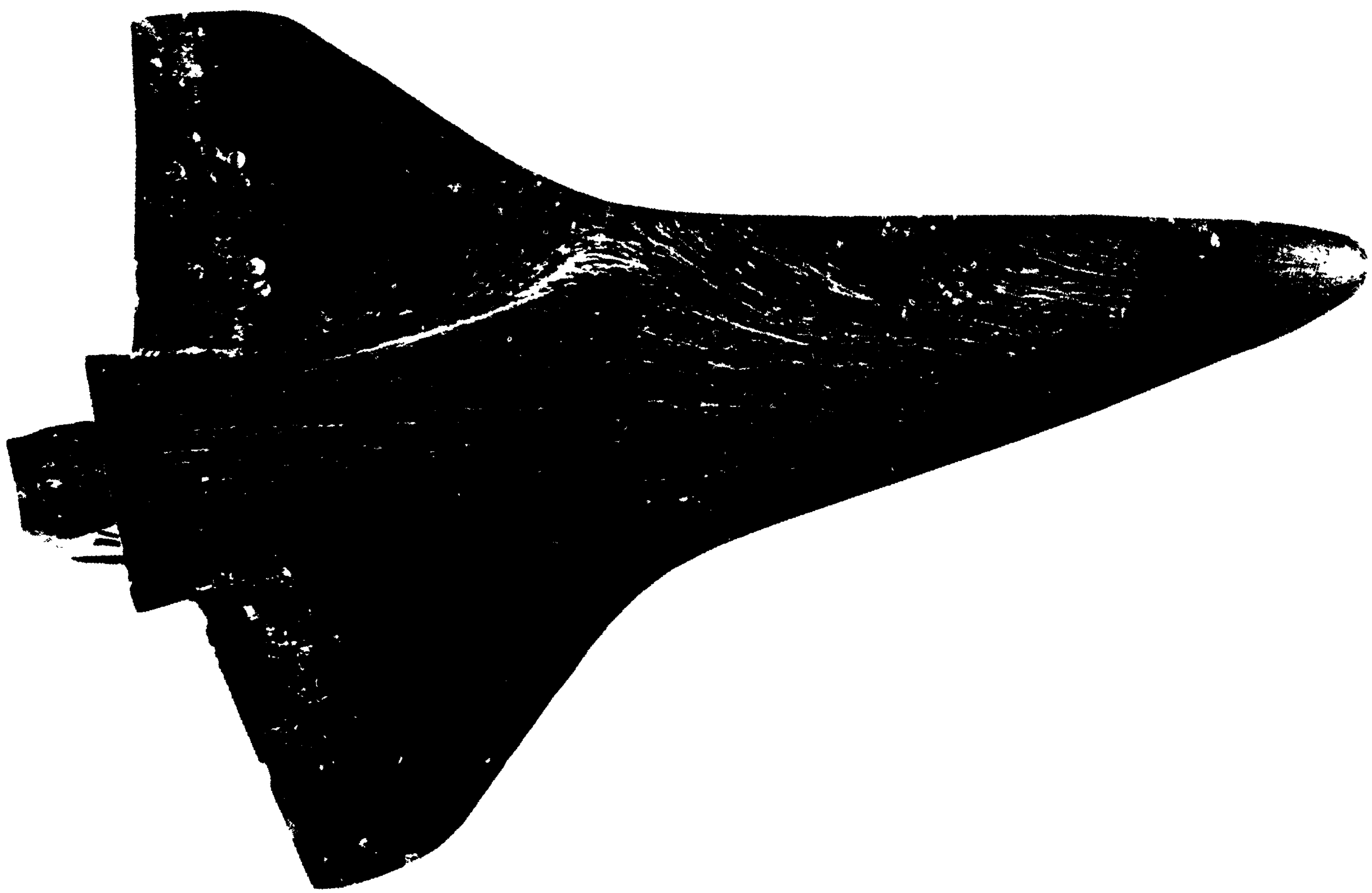


FIGURE 10. (CONTINUED)

F. BOTTOM VIEW

FIGURE 11. OIL FLOW PATTERNS ON THE .01 SCALE MODIFIED ROCKWELL (089B) ORBITER CONFIGURATION AT $\alpha = 20°$, $\beta = 0°$, $\delta_{e_L} = 14°$, $\delta_{e_R} = 6°$, $RN/L = 4.0 \times 10^6$, ROUGHNESS OFF

A. LEFT SIDE VIEW

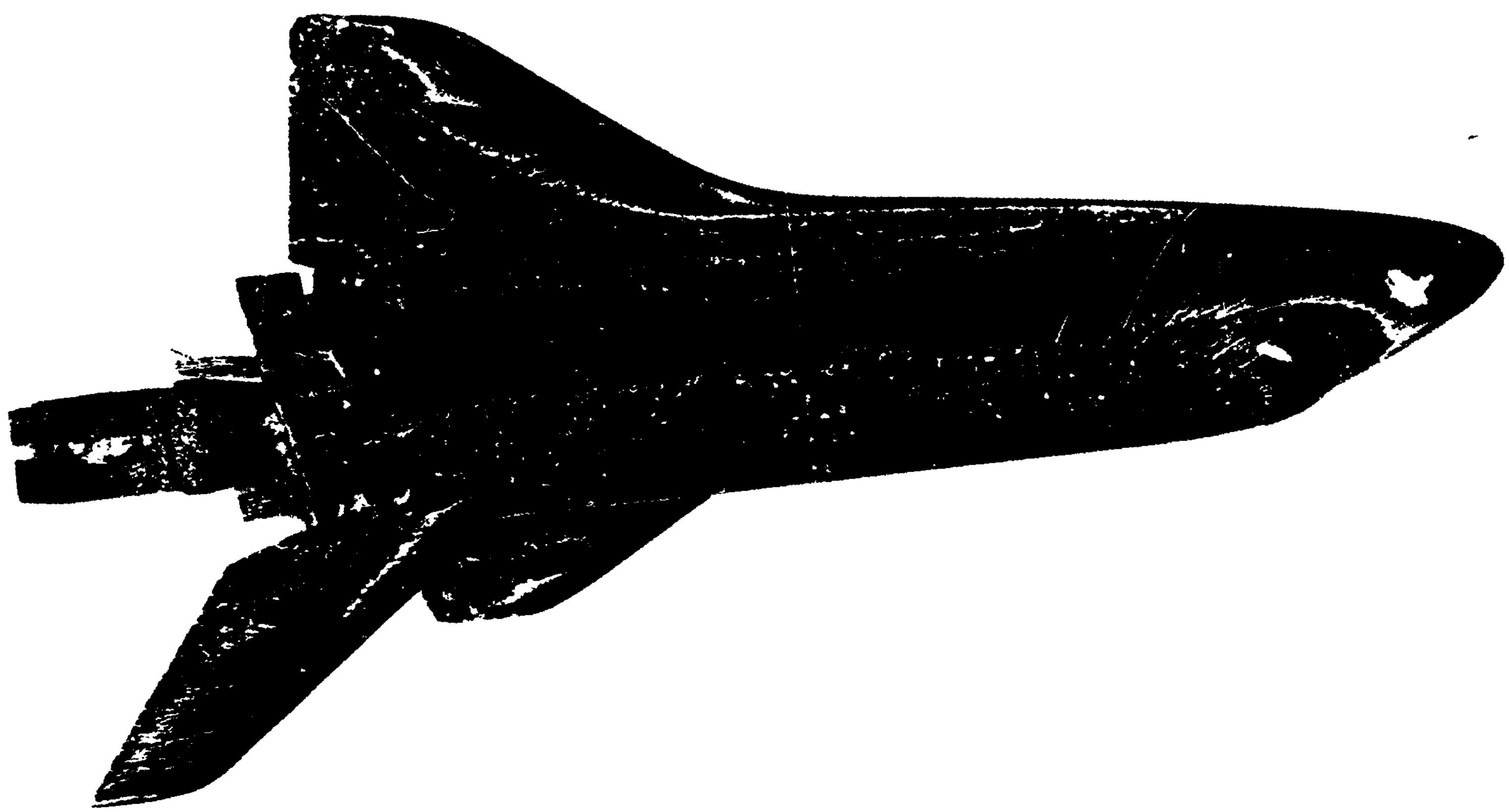


FIGURE 11. (CONTINUED)

B. LEFT WING-BODY JUNCTION VIEW

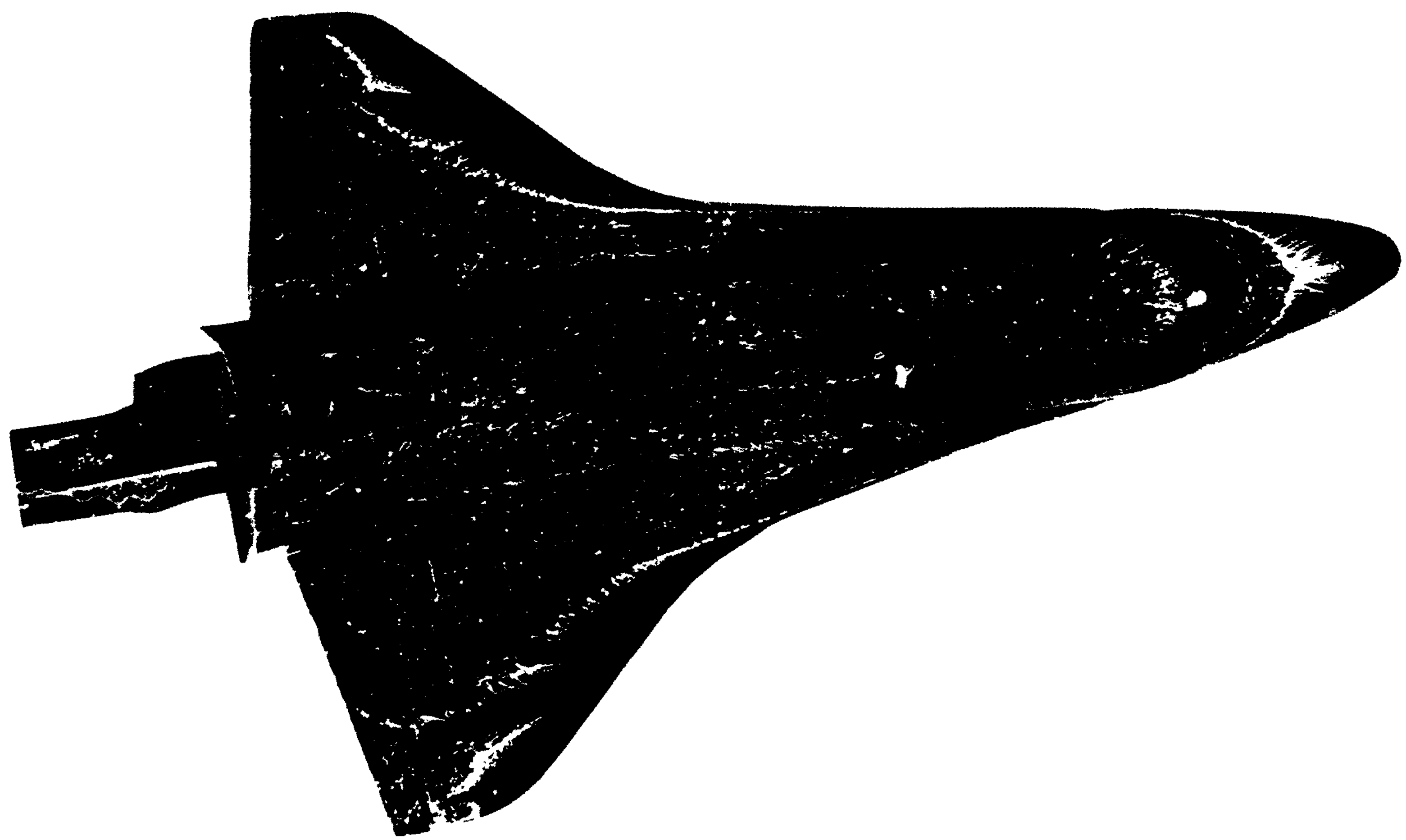


FIGURE 11. (CONTINUED)

C. TOP VIEW

FIGURE 11. (CONTINUED)

D. RIGHT WING-BODY JUNCTION VIEW

FIGURE 11. (CONTINUED)

E. RIGHT SIDE VIEW

FIGURE 11. (CONTINUED)

F. BOTTOM VIEW

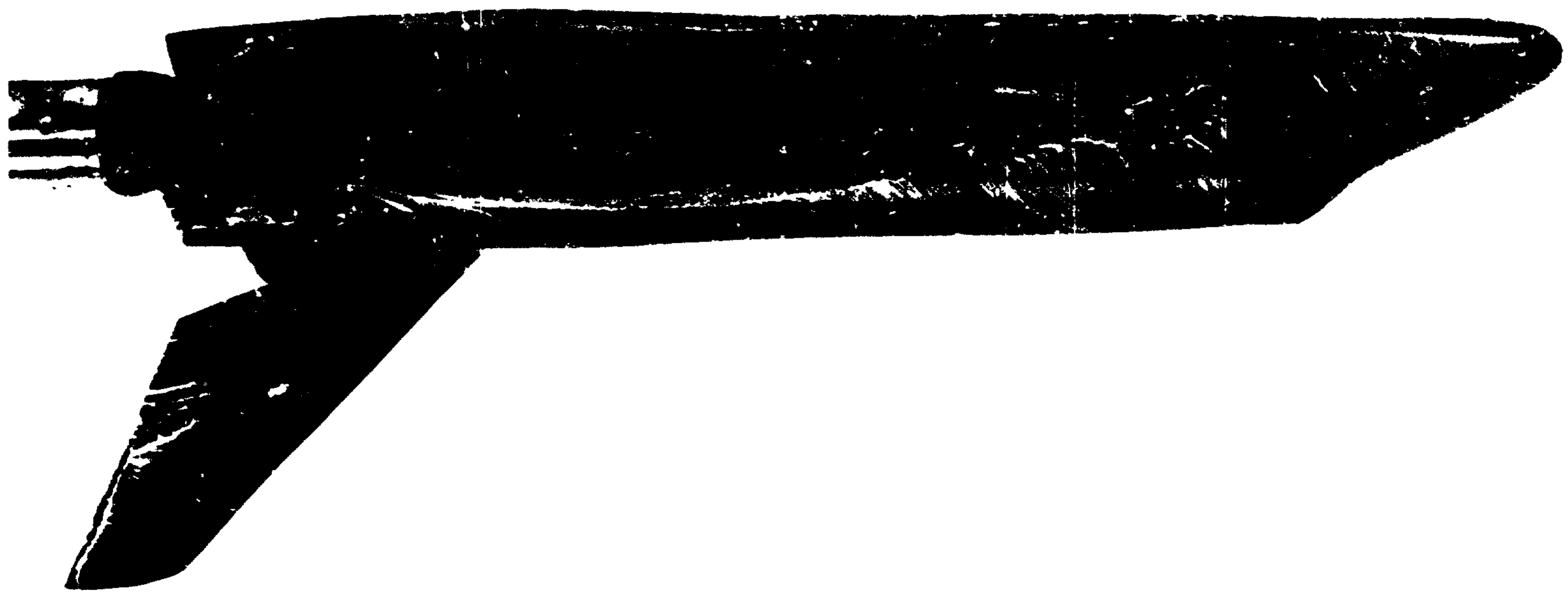


FIGURE 12. OIL FLOW PATTERNS ON THE .01 SCALE MODIFIED ROCKWELL (089B) ORBITER CONFIGURATION AT $\alpha = -25°$, $\beta = 0°$, $\delta_{e_L} = \delta_{e_R} = -30°$, RN/L = 4.0×10^6, ROUGHNESS OFF

A. LEFT SIDE VIEW

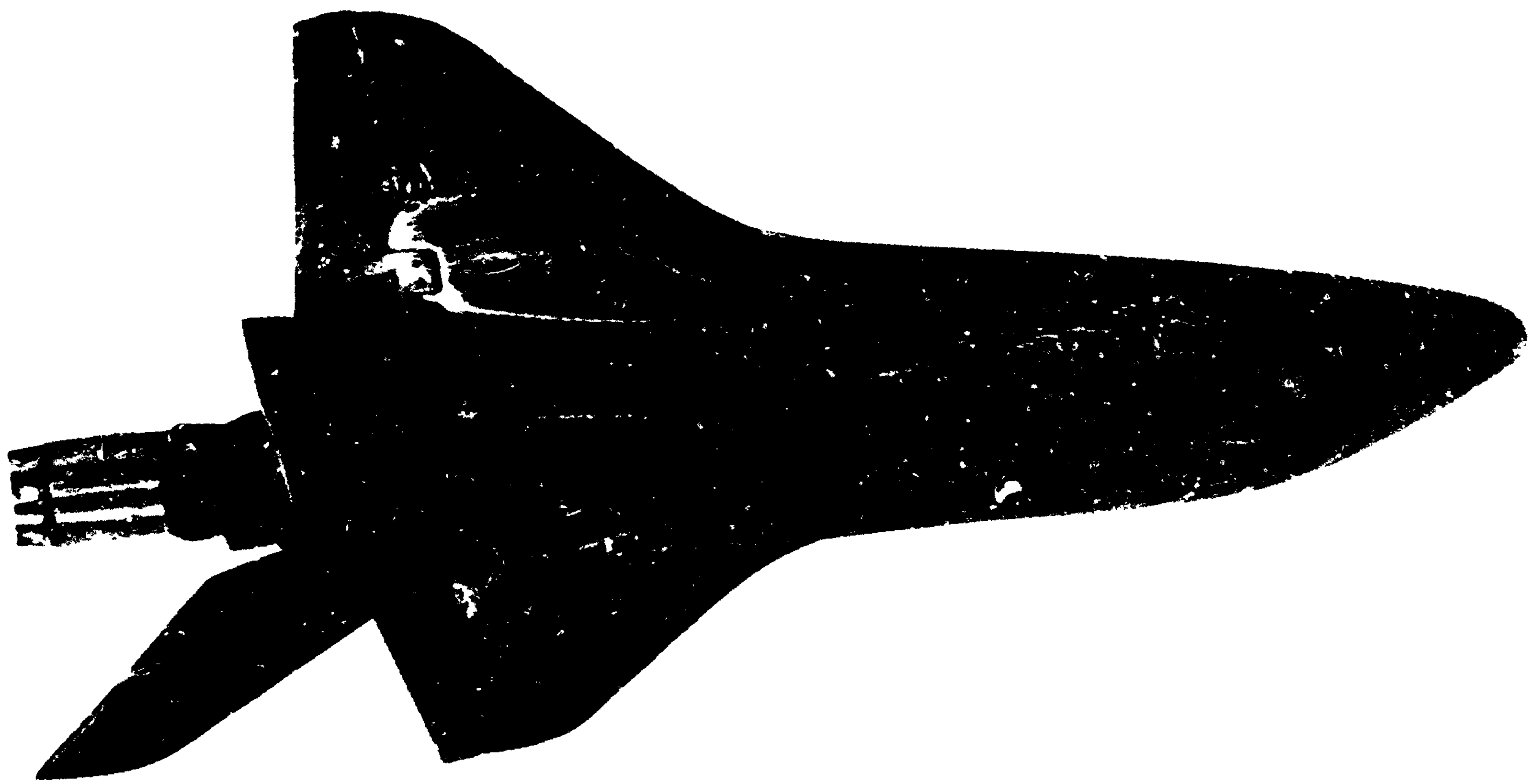


FIGURE 12. (CONTINUED)

B. LEFT WING-BODY JUNCTION VIEW

FIGURE 12. (CONTINUED)

C. TOP VIEW

FIGURE 12. (CONTINUED)

D. RIGHT SIDE VIEW

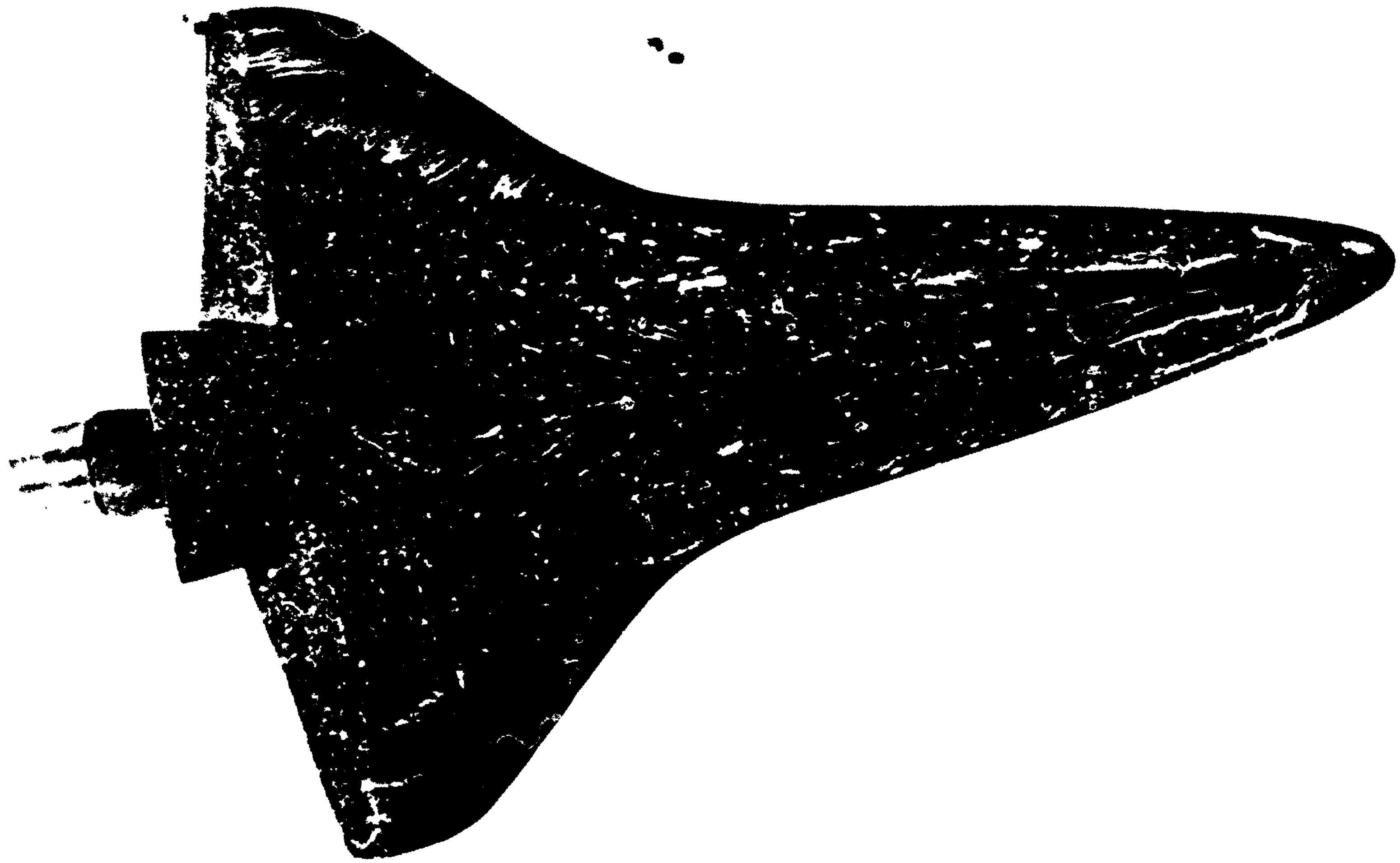


FIGURE 12. (CONTINUED)

E. BOTTOM VIEW

FIGURE 13. OIL FLOW PATTERNS ON THE .01 SCALE MODIFIED ROCKWELL (089B) ORBITER CONFIGURATION AT $\alpha = -25°$, $\beta = +5°$, $\delta_{e_L} = \delta_{e_R} = -30°$, $RN/L = 4.0 \times 10^6$, ROUGHNESS OFF

A. LEFT SIDE VIEW

C-2

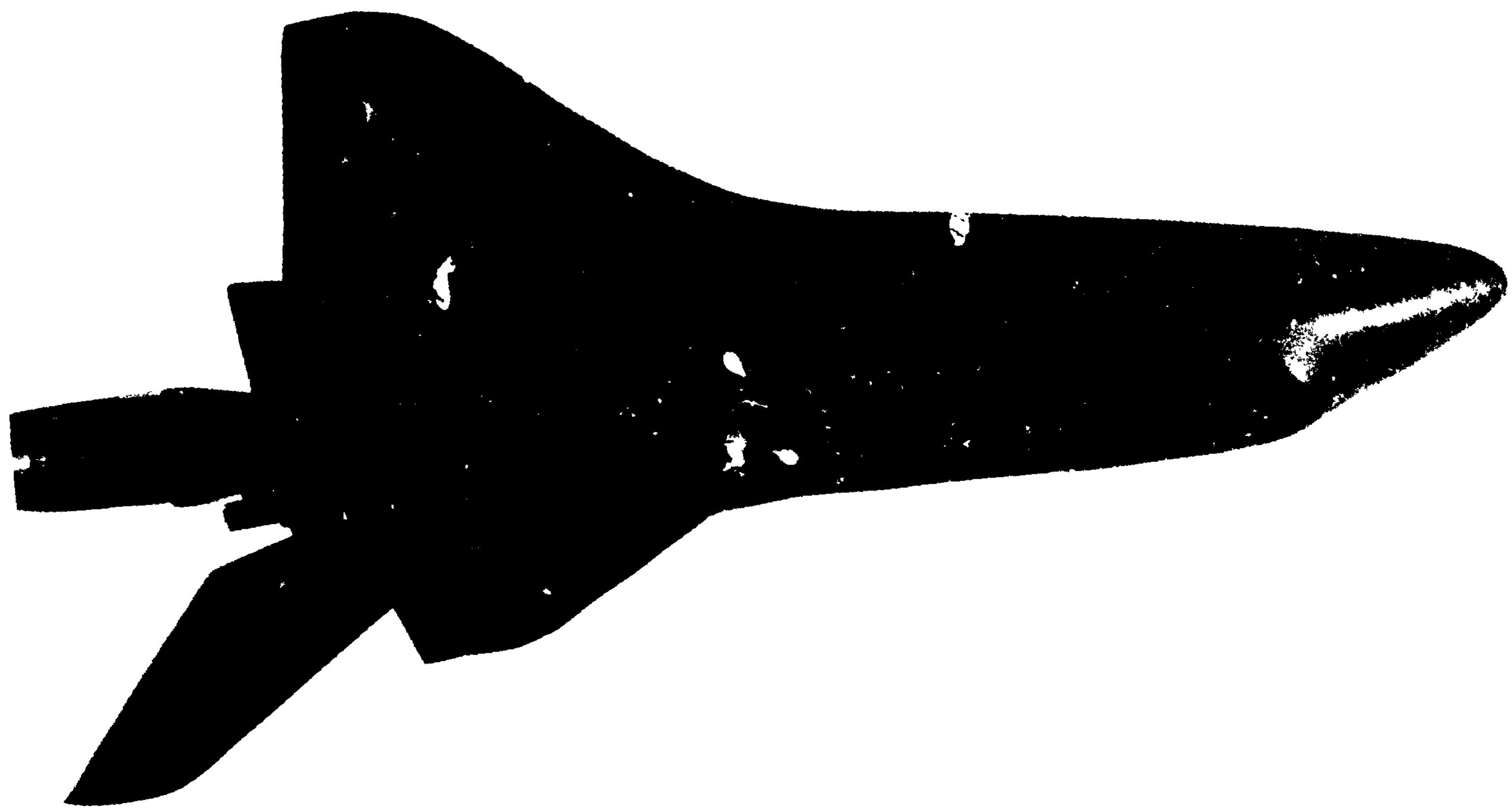


FIGURE 13. (CONTINUED)

B. LEFT WING-BODY JUNCTION VIEW

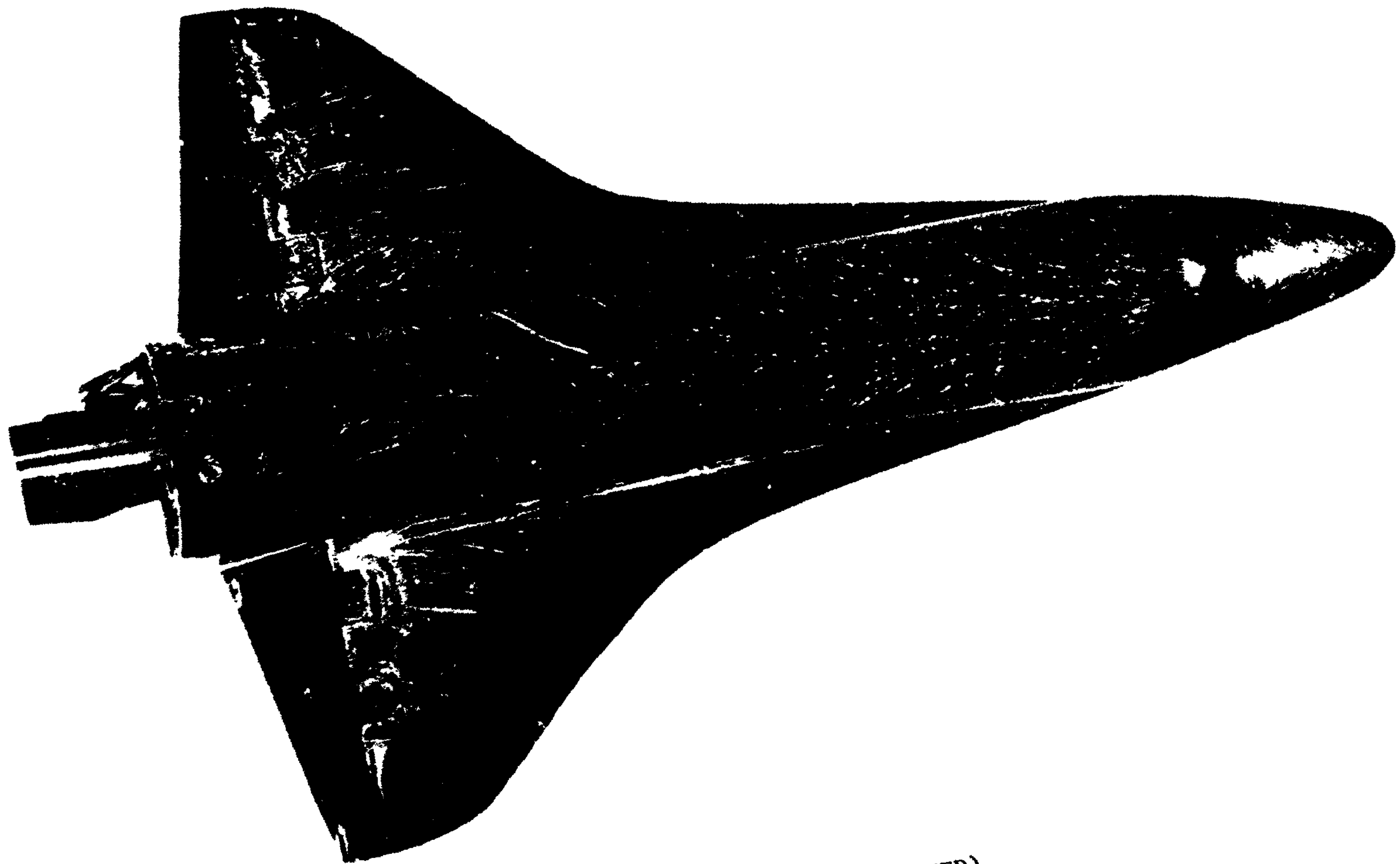


FIGURE 13. (CONTINUED)

C. TOP VIEW

FIGURE 13. (CONTINUED)

D. RIGHT SIDE VIEW

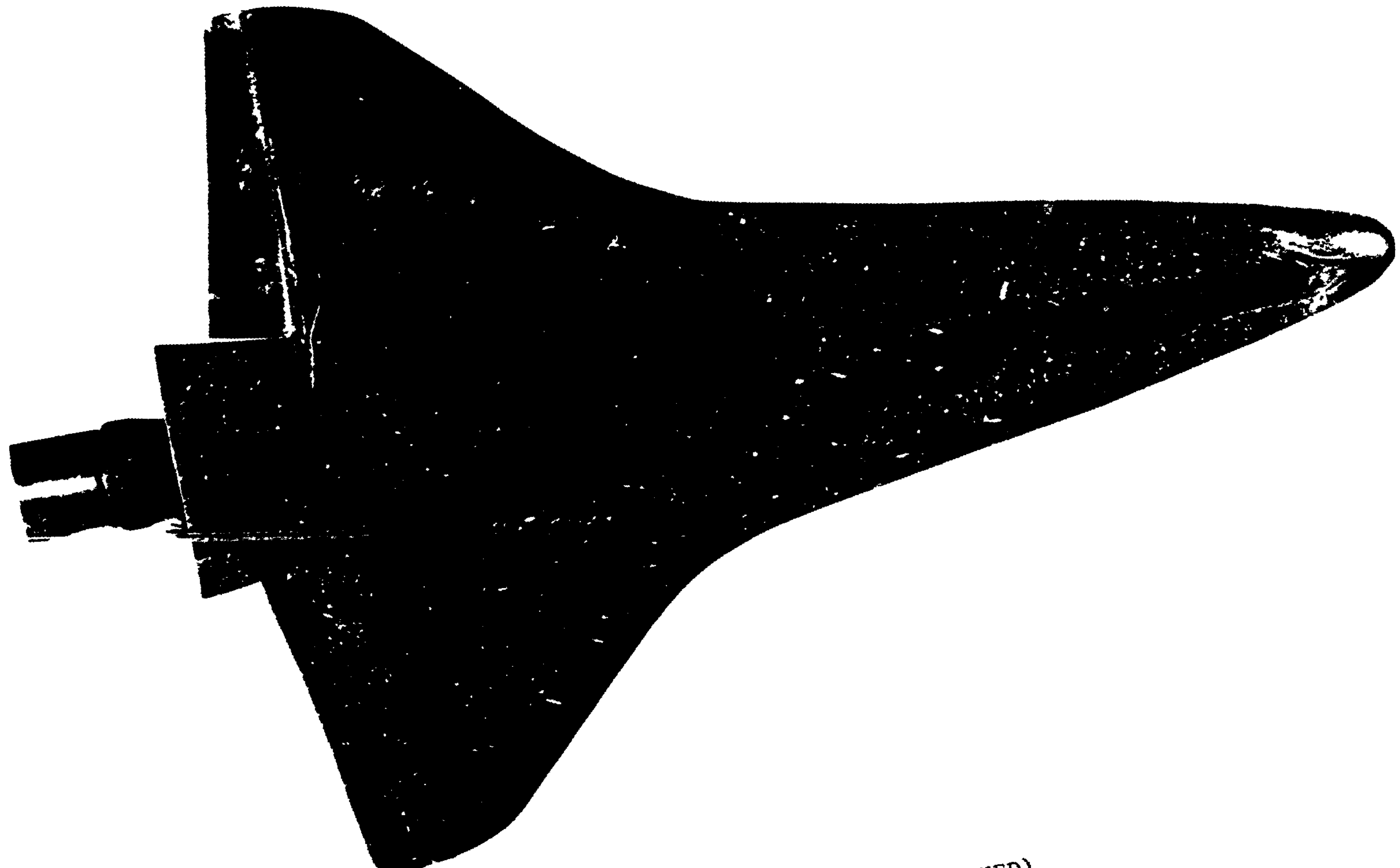


FIGURE 13. (CONTINUED)

E. BOTTOM VIEW

PLOTTED DATA

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(AP-C01)	□	LA-15.ROCKWELL 0898 ORB V/MOD NOSE V/O OMS(BVVF)	.000	.000	-5.000	-5.000
(AP-C02)	○	LA-15.ROCKWELL 0898 ORB V/MOD NOSE V/O OMS(BVVF)	.000	1.000	-5.000	-5.000
(AP-C03)	◇	LA-15.ROCKWELL 0899 ORB V/MOD NOSE V/O OMS(BVVF)	-5.000	.000	-5.000	-5.000
(AP-C04)	△	LA-15.ROCKWELL 0893 ORB V/MOD NOSE V/O OMS(BVVF)	-5.000	1.000	-5.000	-5.000

REFERENCE INFORMATION		
SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

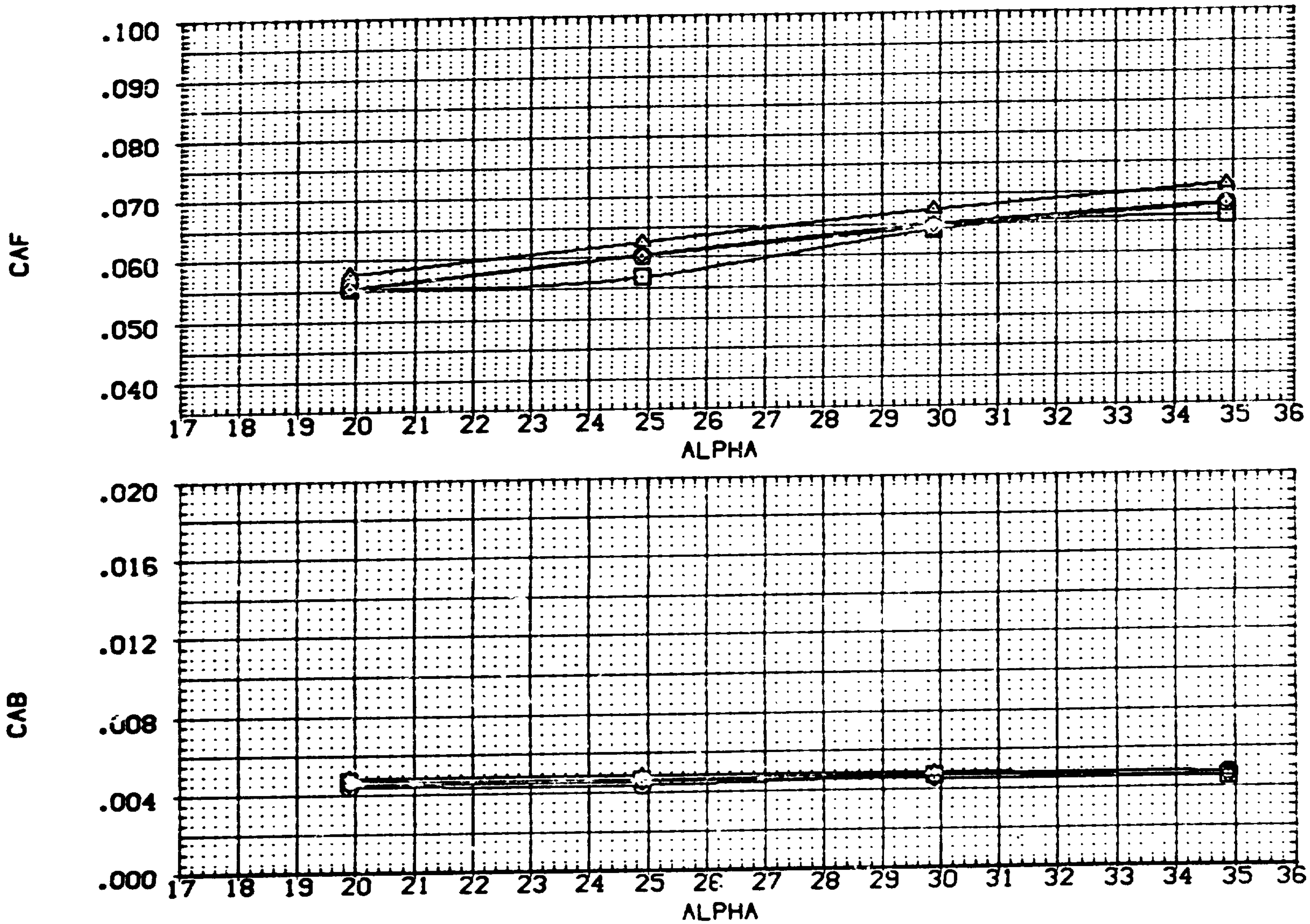


FIGURE 14. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 9.4, ELEVTR= -5)
(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(APCC1)	○	LA-15.ROCKWELL 0893 OR9 V/MOD NOSE V/O OMS(BVVF)	.000	.000	-5.000	-5.000
(APCC2)	□	LA-15.ROCKWELL 0893 OR9 V/MOD NOSE V/O OMS(BVVF)	.000	1.000	-5.000	-5.000
(APCC3)	◇	LA-15.ROCKWELL 0893 OR9 V/MOD NOSE V/O OMS(BVVF)	-5.000	.000	-5.000	-5.000
(APCC4)	△	LA-15.ROCKWELL 0893 OR9 V/MOD NOSE V/O OMS(BVVF)	-5.000	1.000	-5.000	-5.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

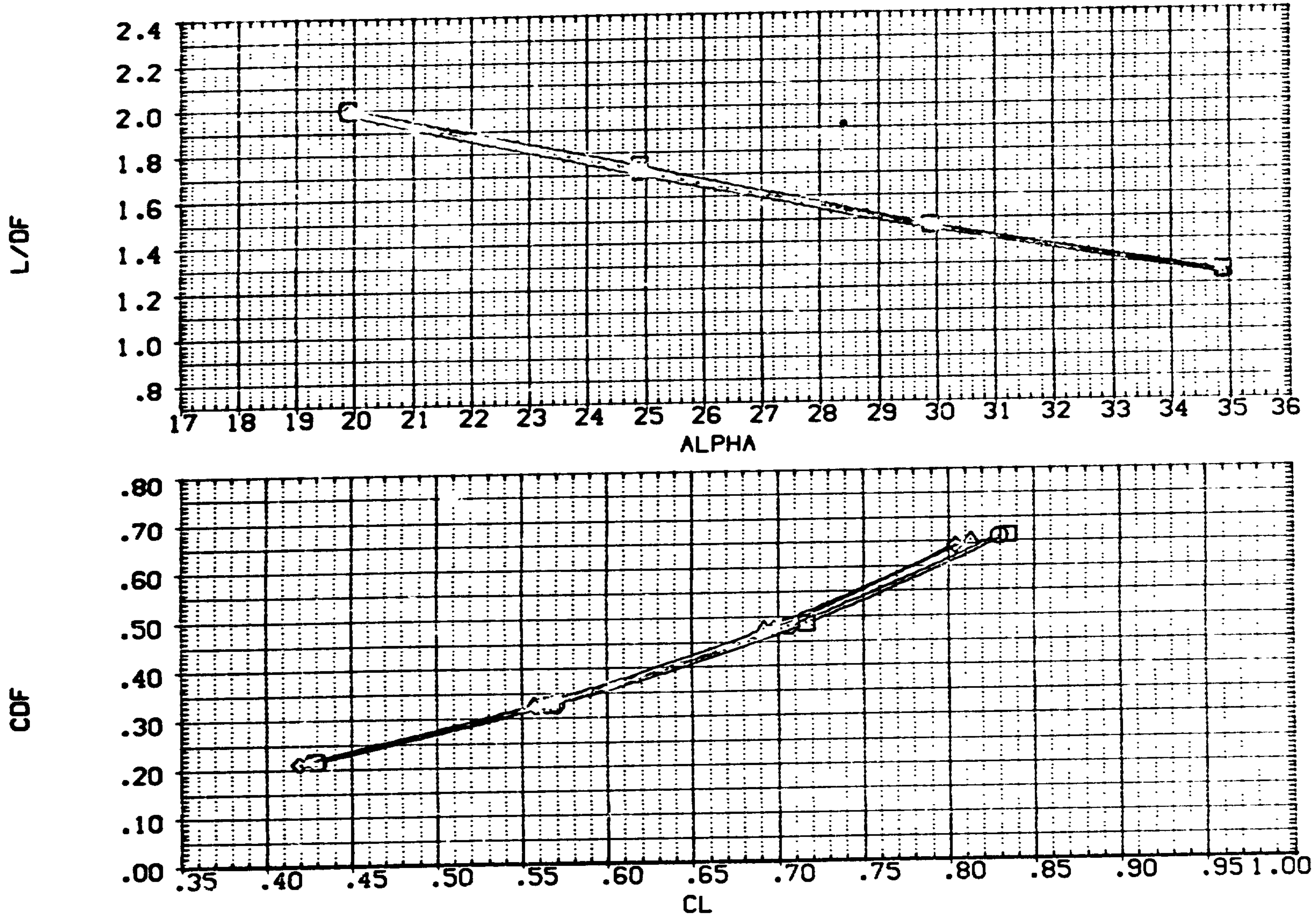


FIGURE 14. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 9.4, ELEVTR= -5)

(A)MACH = 6.00

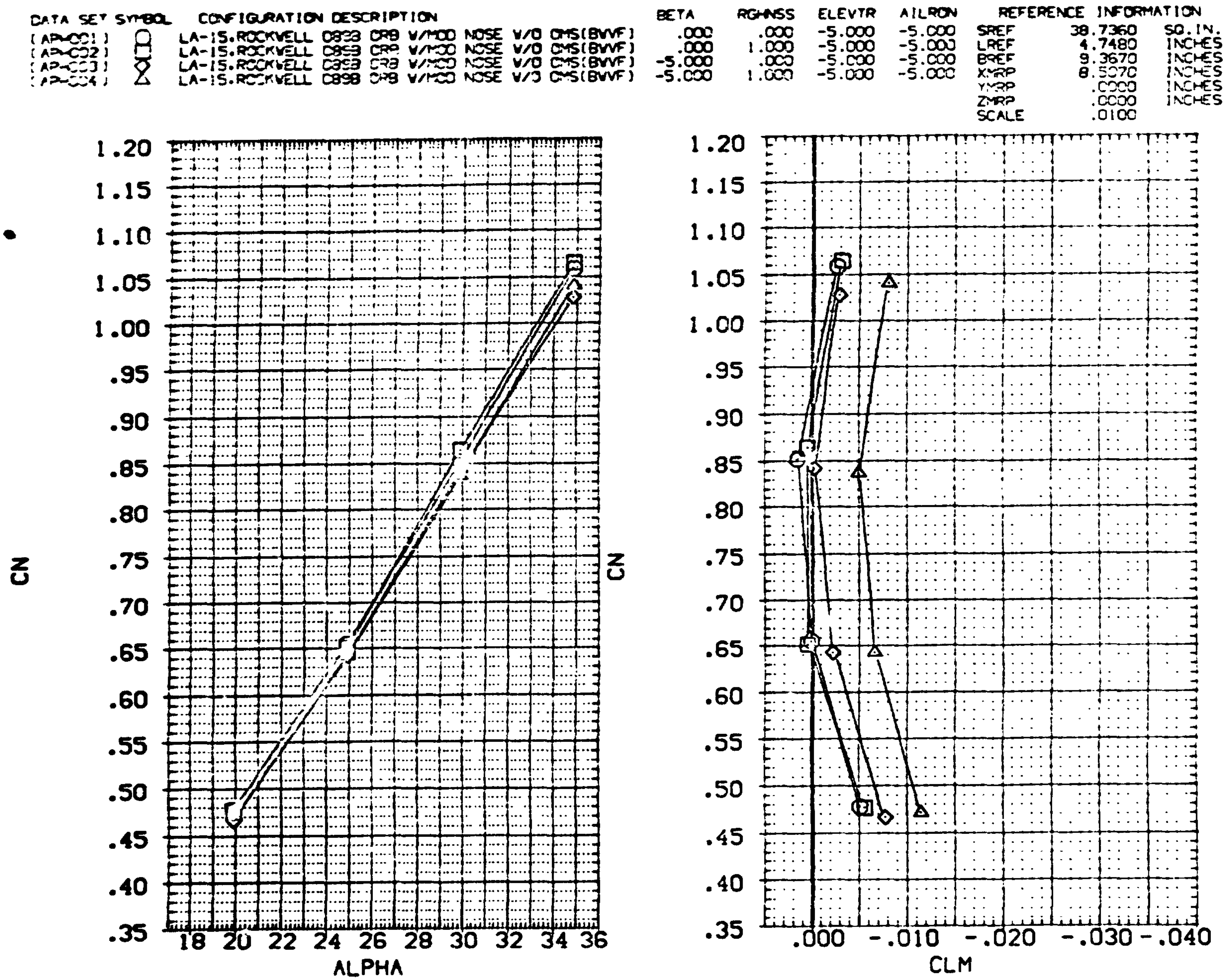


FIGURE 14. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 9.4, ELEVTR= -5)

(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(AP-C01)	○	LA-15.ROCKWELL O893 ORB W/MOD NOSE W/O OMS(BWVF)	.000	.000	-5.000	-5.000
(AP-C02)	□	LA-15.ROCKWELL O893 ORB W/MOD NOSE W/O OMS(BWVF)	.000	1.000	-5.000	-5.000
(AP-C03)	◇	LA-15.ROCKWELL O893 ORB W/MOD NOSE W/O OMS(BWVF)	-5.000	.000	-5.000	-5.000
(AP-C04)	△	LA-15.ROCKWELL O893 ORB W/MOD NOSE W/O OMS(BWVF)	-5.000	1.000	-5.000	-5.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.0070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

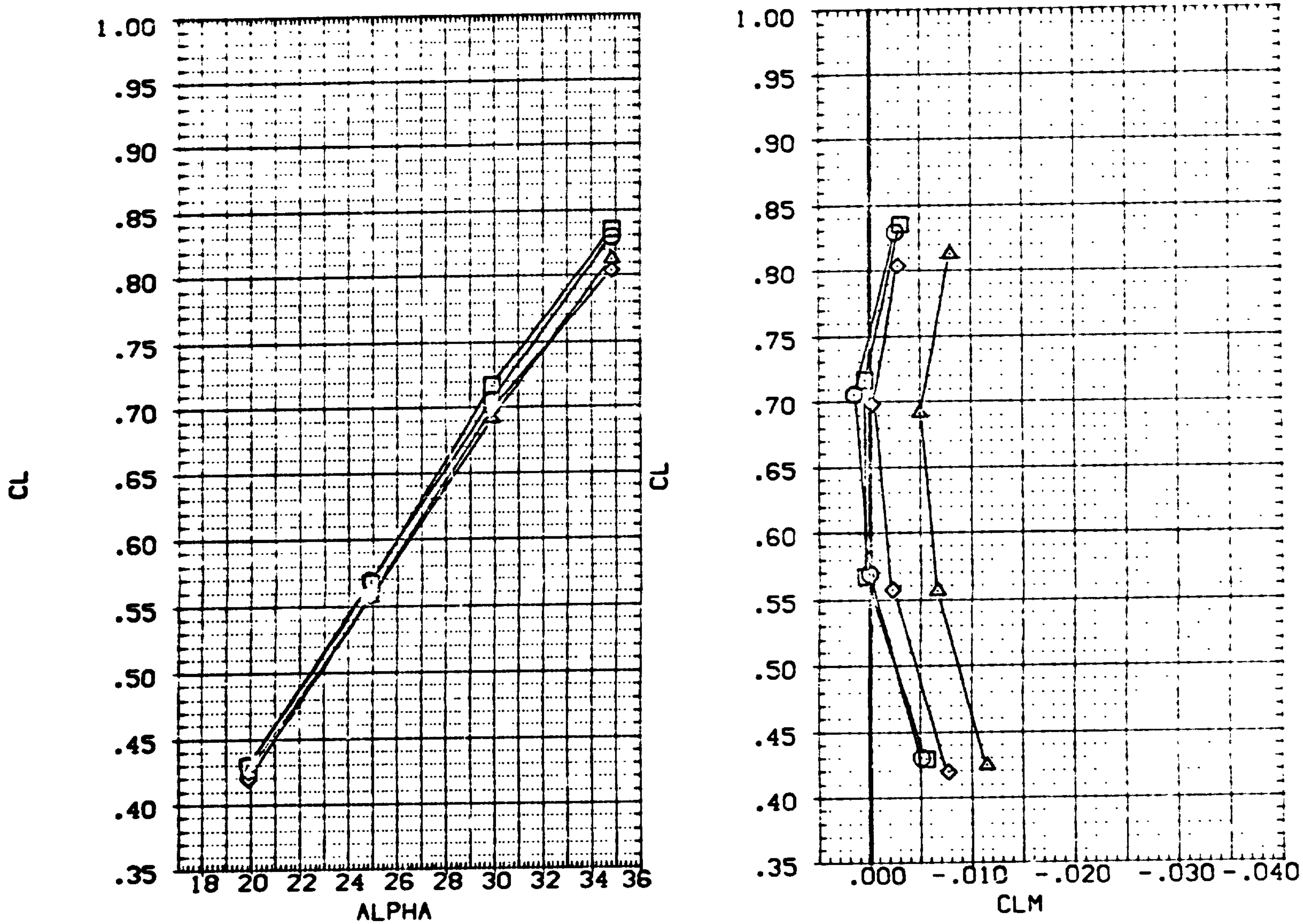


FIGURE 14. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 9.4, ELEVTR= -5)
(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	RGHNSS	ELEVTR	AILRON
(2P-C01)	○	LA-15.ROCKWELL 0898 ORB W/MOD NOSE W/O OMS(BWVF)	.000	-5.000	-5.000
(2P-C02)	□	LA-15.ROCKWELL 0898 ORB W/MOD NOSE W/O OMS(BWVF)	1.000	-5.000	-5.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

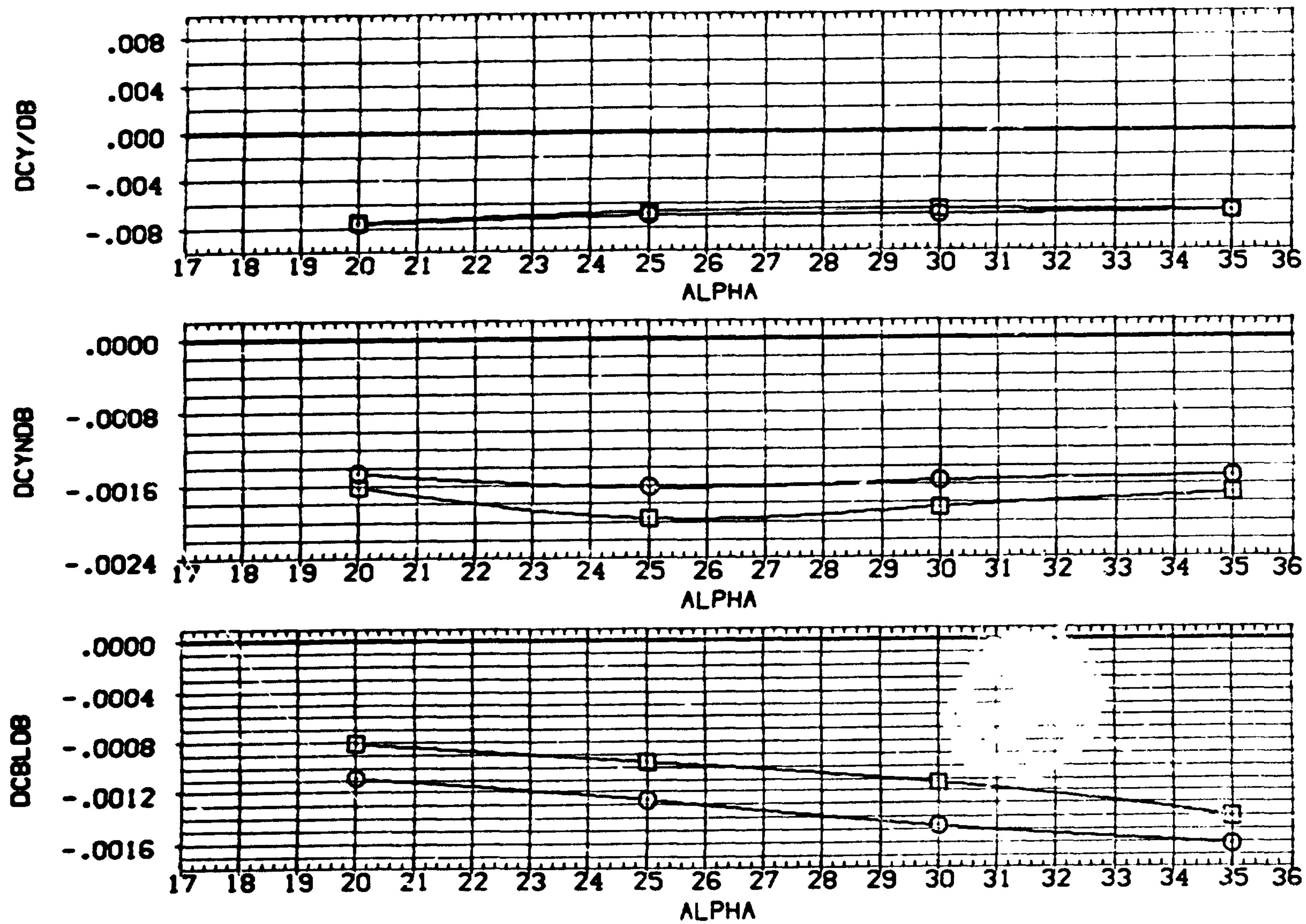


FIGURE 14. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 9.4, ELEVTR= -5)

(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(DP+001)	○	LA-15.ROCKWELL O89B ORB V/MOD NOSE V/C OMS(BVVF)	.000	.000	-5.000	-5.000
(DP+002)	□	LA-15.ROCKWELL O89B ORB V/MOD NOSE V/O OMS(BVVF)	.000	1.000	-5.000	-5.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

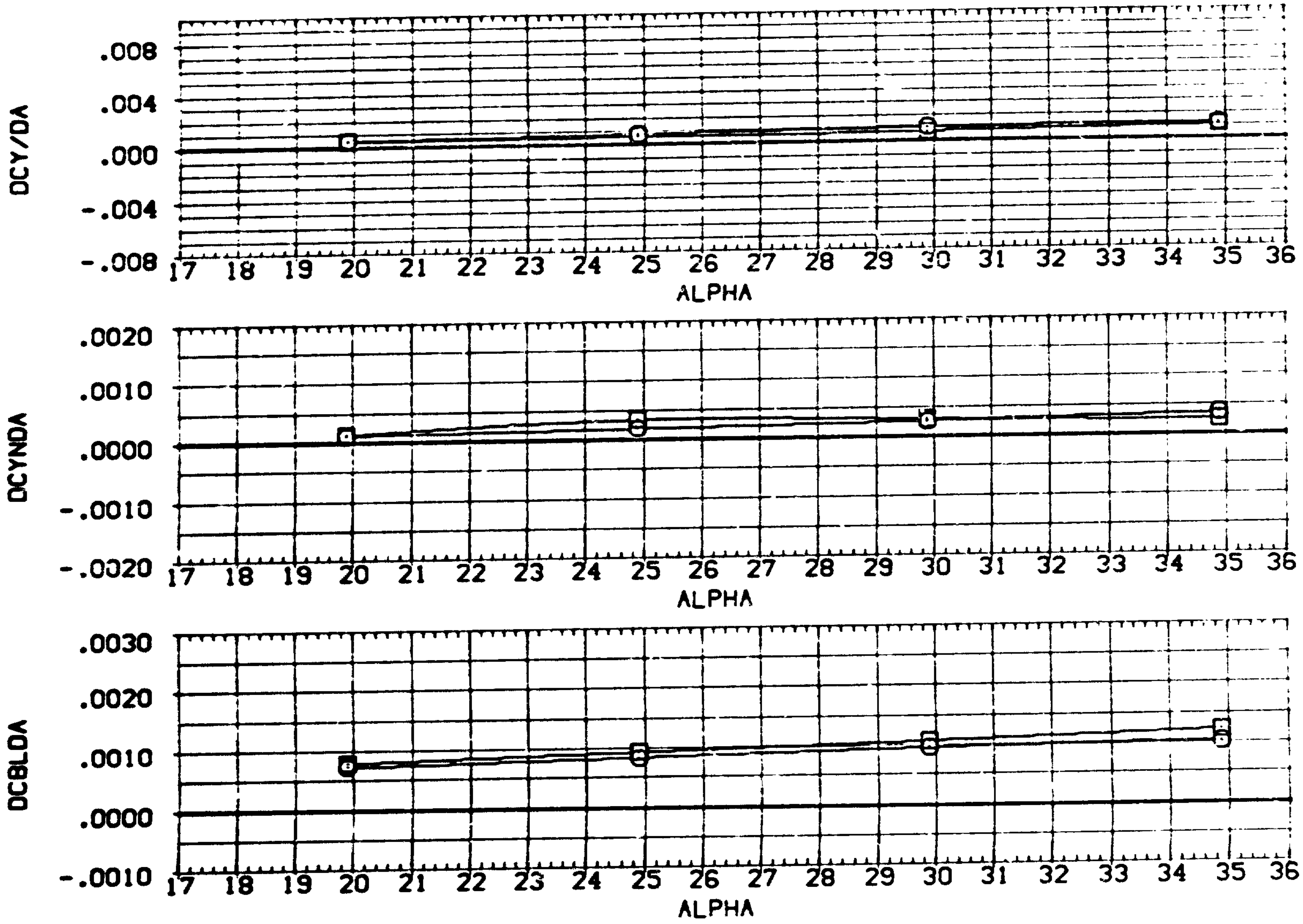


FIGURE 14. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 9.4, ELEVTR= -5)

(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(AP-005)		LA-15.ROCKWELL 0898 ORB W/MOD NOSE W/O OMS(BWVF)	.000	.000	10.000	4.000
(AP-006)		LA-15.ROCKWELL 0899 ORB W/MOD NOSE W/O OMS(BWVF)	.000	1.000	10.000	4.000
(AP-007)		LA-15.ROCKWELL 0899 ORB W/MOD NOSE W/O OMS(BWVF)	-5.000	.000	10.000	4.000
(AP-008)		LA-15.ROCKWELL 0899 ORB W/MOD NOSE W/O OMS(BWVF)	-5.000	1.000	10.000	4.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

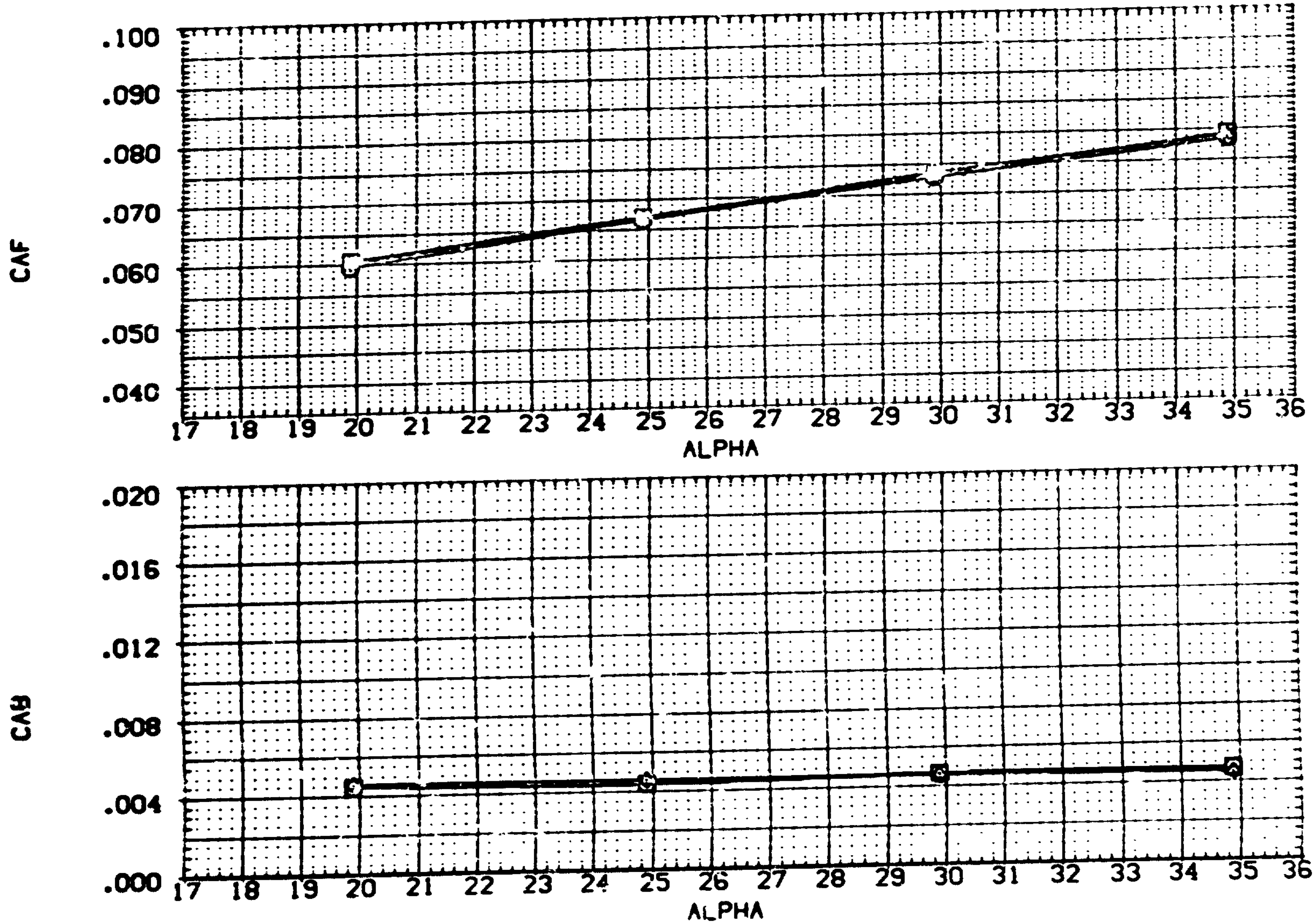


FIGURE 15. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 9.4, ELEVTR= 10)

(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(APH005)	○	LA-15.ROCKWELL 0893 CRB V/MOD NOSE V/O OMS(BVVF)	.000	.000	10.000	4.000
(APH006)	□	LA-15.ROCKWELL 0893 CRB V/MOD NOSE V/O OMS(BVVF)	.000	1.000	10.000	4.000
(APH007)	◇	LA-15.ROCKWELL 0893 CRB V/MOD NOSE V/O OMS(BVVF)	-5.000	.000	10.000	4.000
(APH008)	△	LA-15.ROCKWELL 0893 CRB V/MOD NOSE V/O OMS(BVVF)	-5.000	1.000	10.000	4.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5370	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

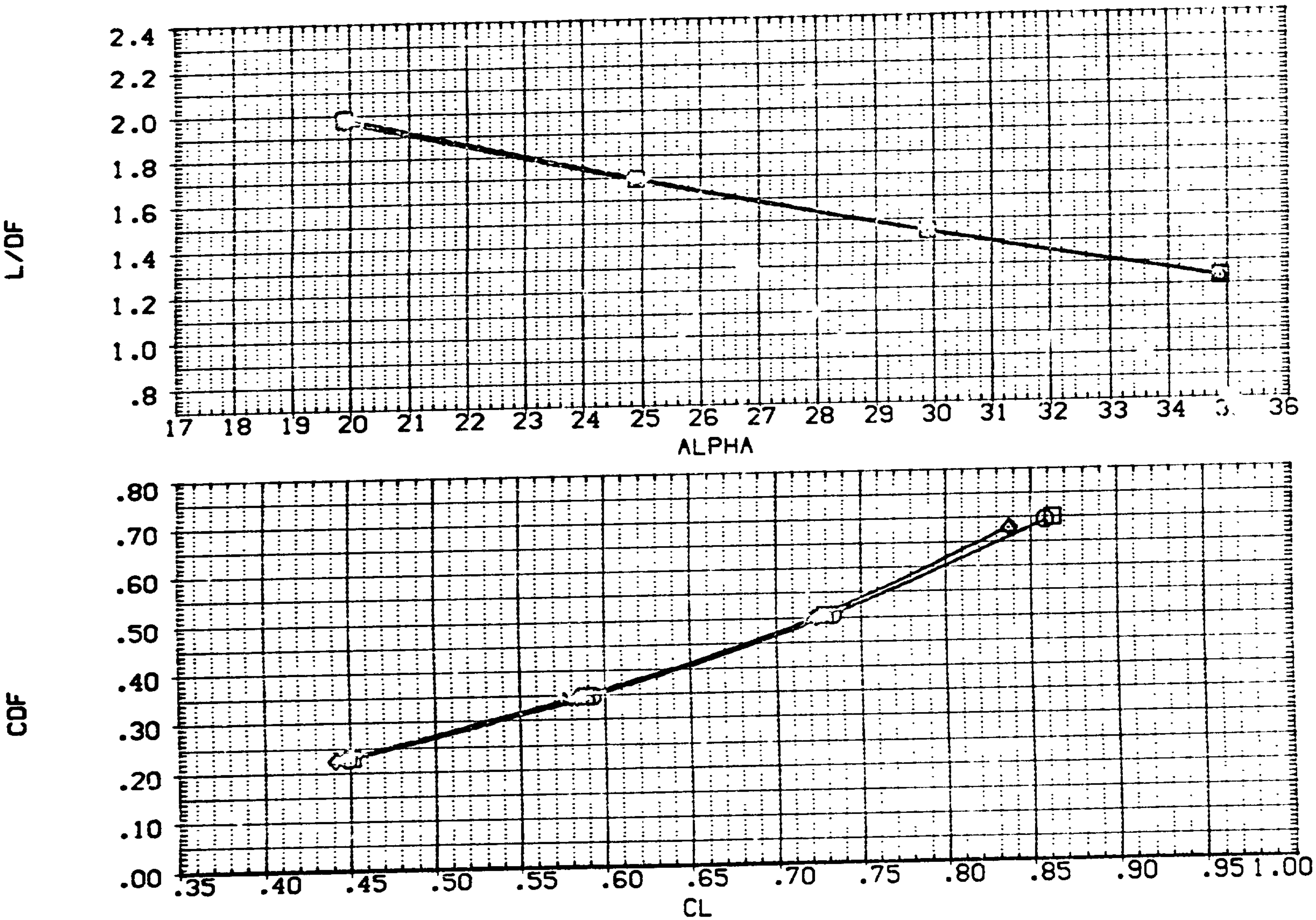


FIGURE 15. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 9.4, ELEVTR= 10)

(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(APHOC5)	○	LA-15.ROCKWELL 0893 ORB V/MOD NOSE V/O OMS(BVVF)	.000	.000	10.000	4.000
(APHOC6)	□	LA-15.ROCKWELL 0896 ORB V/MOD NOSE V/O OMS(BVVF)	.000	1.000	10.000	4.000
(APHOC7)	◇	LA-15.ROCKWELL 0893 ORB V/MOD NOSE V/O OMS(BVVF)	-5.000	.000	10.000	4.000
(APHOC8)	△	LA-15.ROCKWELL 0893 ORB V/MOD NOSE V/O OMS(BVVF)	-5.000	1.000	10.000	4.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	.0070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

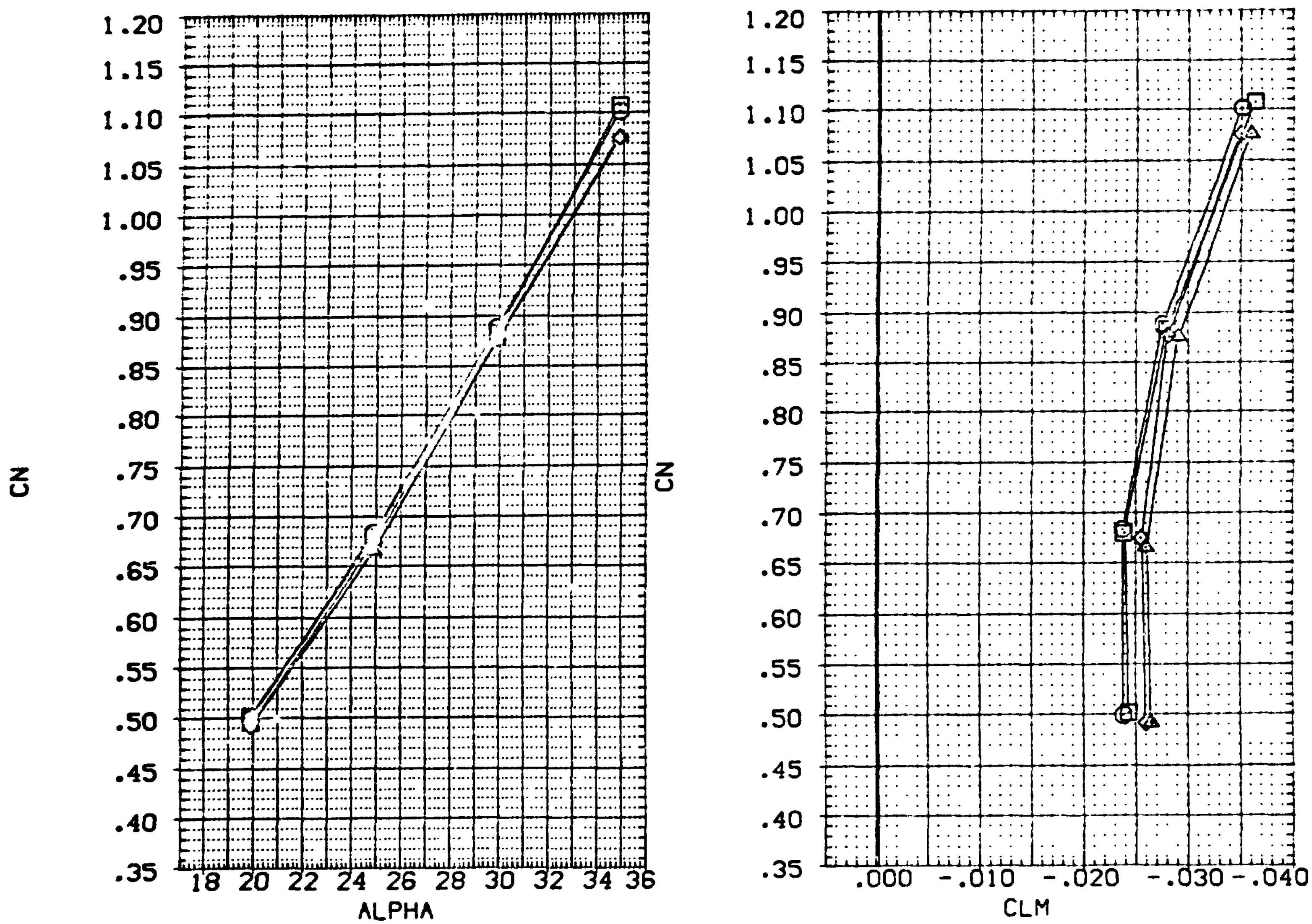


FIGURE 15. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 9.4, ELEVTR= 10)

(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(APH005)	○	LA-15.ROCKWELL 0898 CRB W/MOD NOSE W/O OMS(BWVF)	.000	.000	10.000	4.000
(APH006)	□	LA-15.ROCKWELL 0898 CRB W/MOD NOSE W/O OMS(BWVF)	.000	1.000	10.000	4.000
(APH007)	◇	LA-15.ROCKWELL 0898 CRB W/MOD NOSE W/O OMS(BWVF)	-5.000	.000	10.000	4.000
(APH008)	△	LA-15.ROCKWELL 0898 CRB W/MOD NOSE W/O OMS(BWVF)	-5.000	1.000	10.000	4.000

REFERENCE INFORMATION		
SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

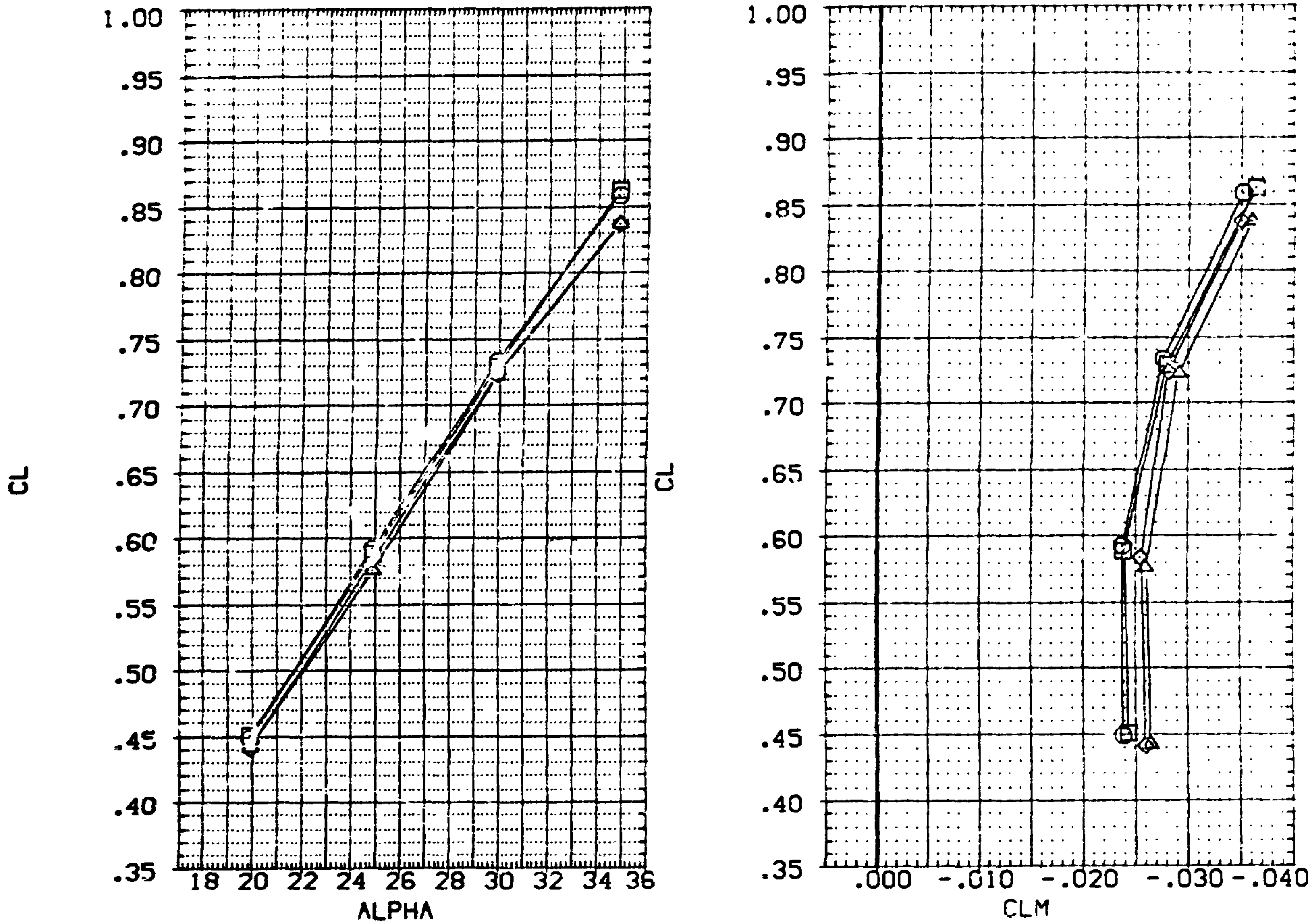


FIGURE 15. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 9.4, ELEVTR= 10)

(A)MACH = 6.00

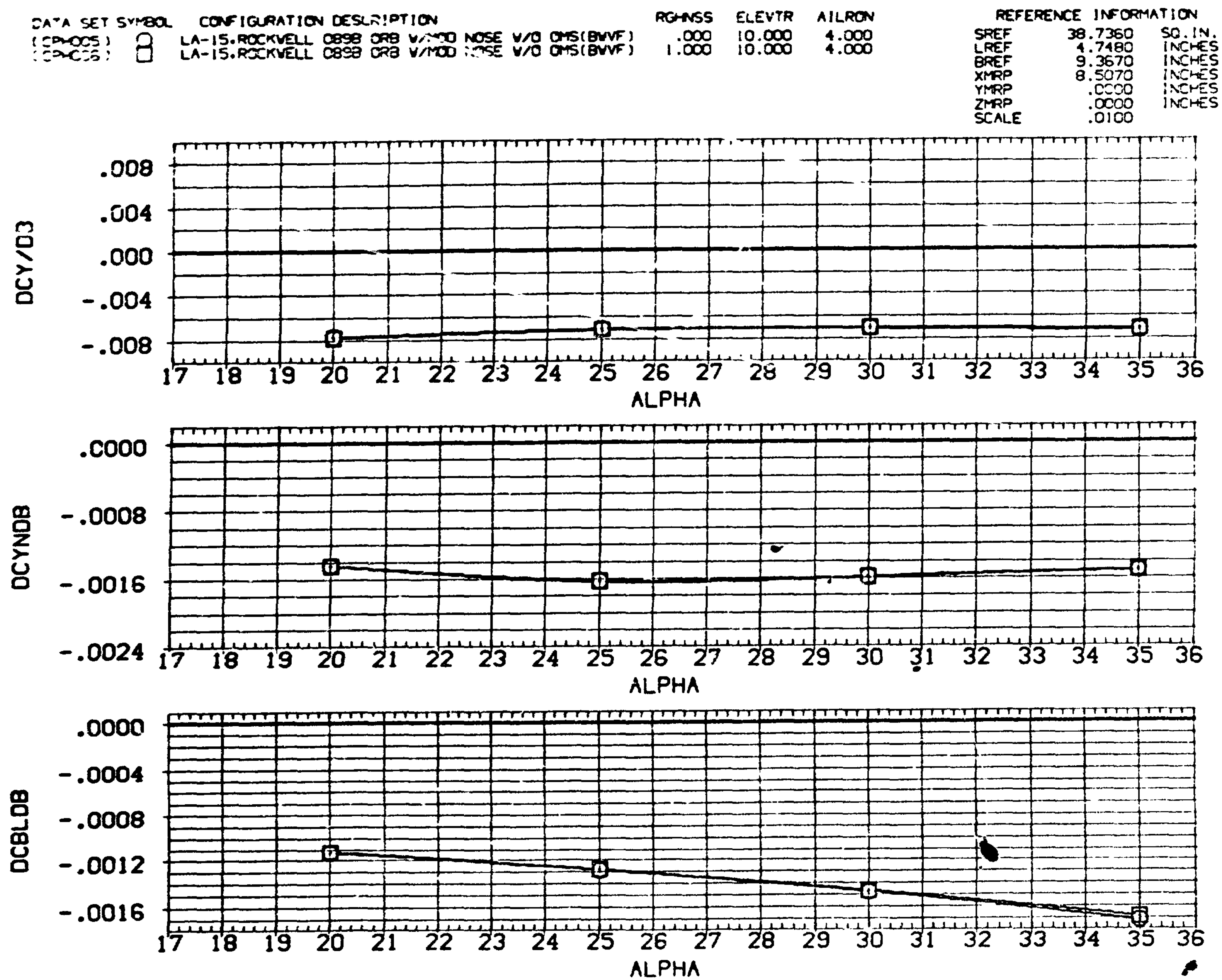


FIGURE 15. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 9.4, ELEVTR= 10)

(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(DPH005)	○	LA-15,ROCKWELL 0898 ORB W/MOD NOSE W/O OMS(BWVF)	.000	.000	10.000	4.000
(DPH006)	□	LA-15,ROCKWELL 0898 ORB W/MOD NOSE W/O OMS(BWVF)	.000	1.000	10.000	4.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

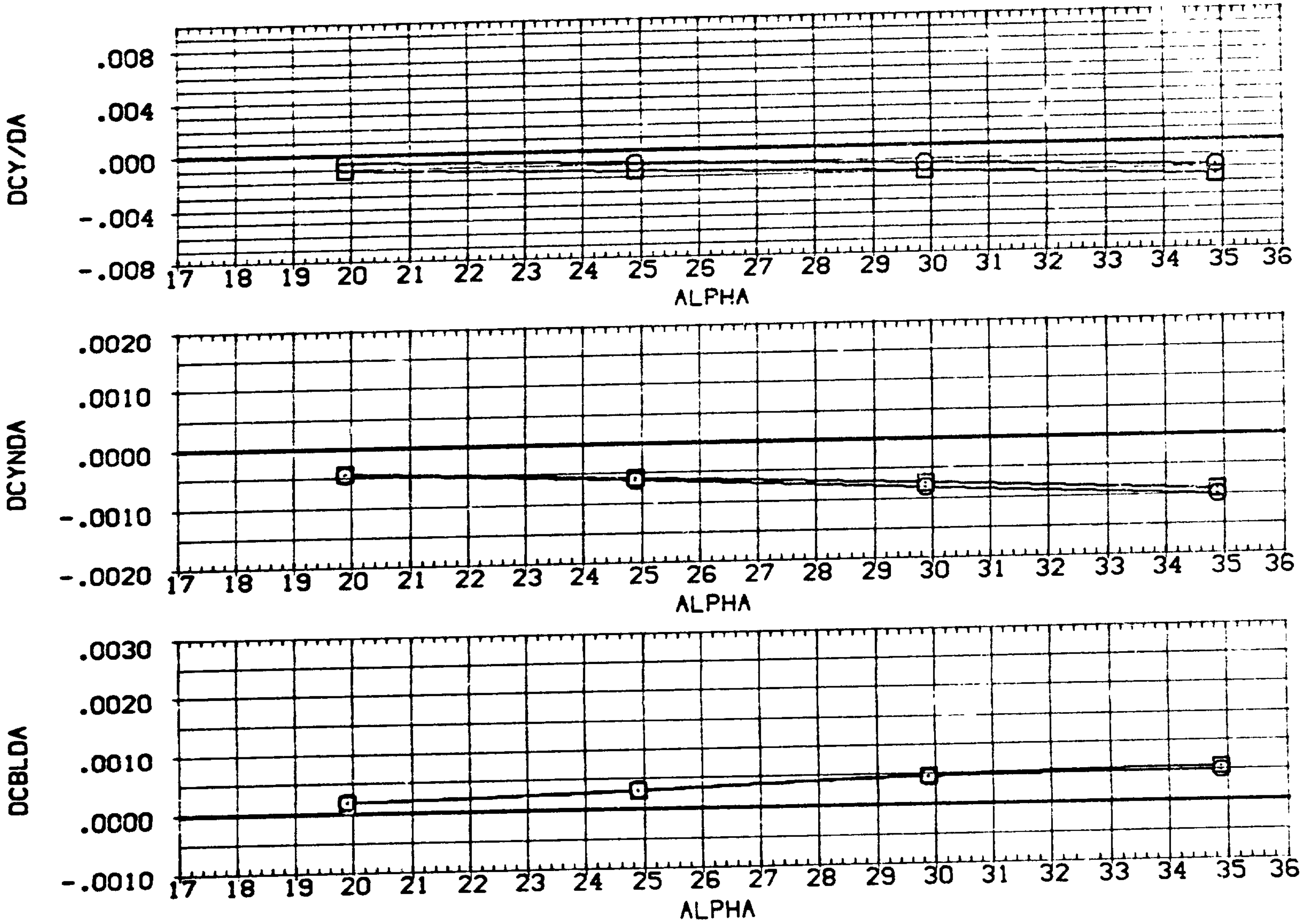


FIGURE 15. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 9.4, ELEVTR= 10)

(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(AP-C09)	□	LA-15.ROCKWELL C893 CR8 V/MOD NOSE V/O OMS(BVVF)	.000	.000	-5.000	-5.000
(AP-O10)	◇	LA-15.ROCKWELL C893 CR8 V/MOD NOSE V/O OMS(BVVF)	.000	1.000	-5.000	-5.000
(AP-O11)	⌂	LA-15.ROCKWELL C893 CR8 V/MOD NOSE V/O OMS(BVVF)	-5.000	.000	-5.000	-5.000
(AP-O12)	△	LA-15.ROCKWELL C893 CR8 V/MOD NOSE V/O OMS(BVVF)	-5.000	1.000	-5.000	-5.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

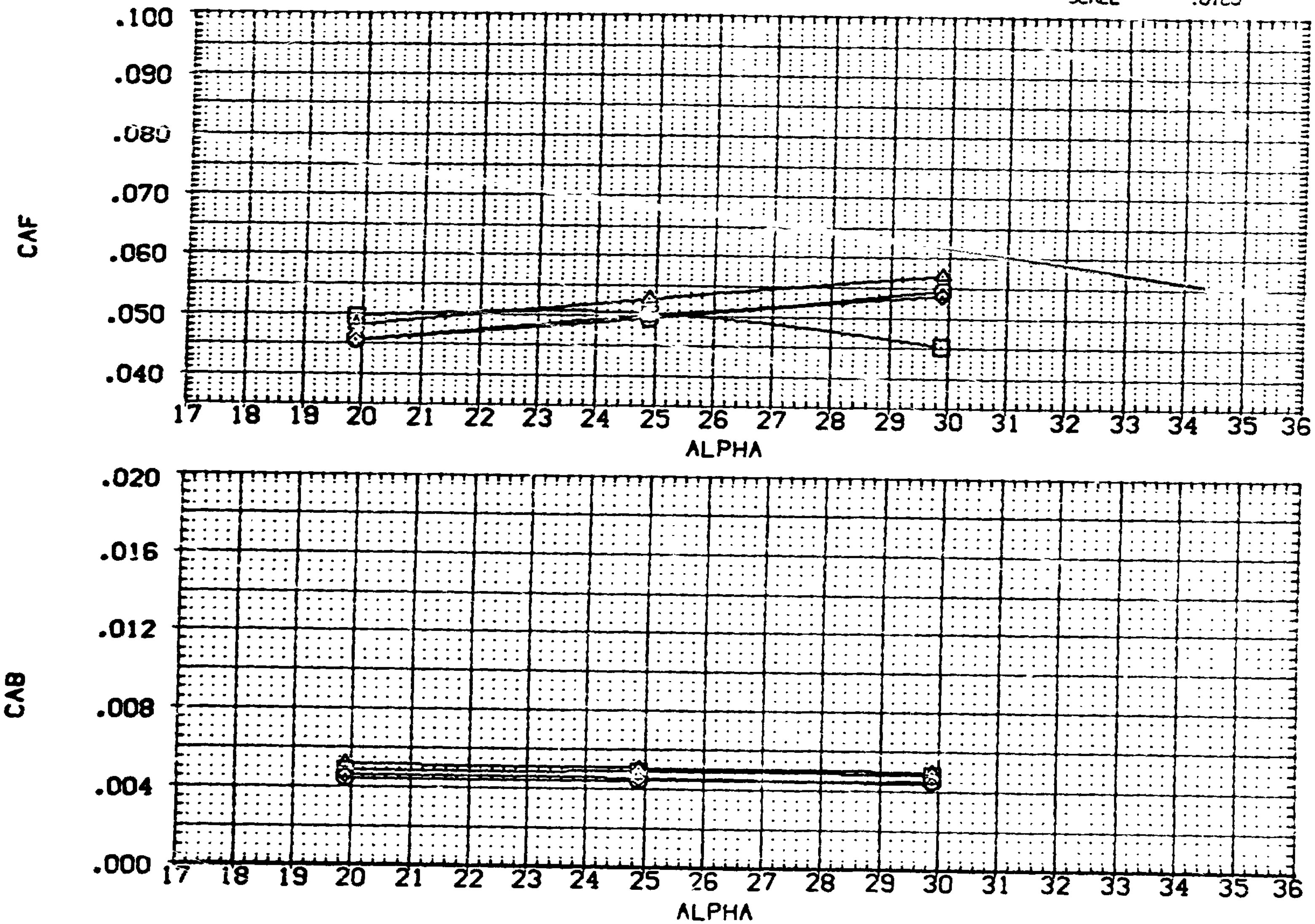


FIGURE 16. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 4.0, ELEVTR= -5)
(A)MACH = 5.93

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(APHC09)	◻	LA-15.ROCKWELL 0898 ORB W/MOD NOSE W/O OMS(BVVF)	.000	.000	-5.000	-5.000
(APHC10)	○	LA-15.ROCKWELL 0898 ORB W/MOD NOSE W/O OMS(BVVF)	.000	1.000	-5.000	-5.000
(APHC11)	◇	LA-15.ROCKWELL 0898 ORB W/MOD NOSE W/O OMS(BVVF)	-5.000	.000	-5.000	-5.000
(APHC12)	△	LA-15.ROCKWELL 0898 ORB W/MOD NOSE W/O OMS(BVVF)	-5.000	1.000	-5.000	-5.000

REFERENCE INFORMATION		
SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

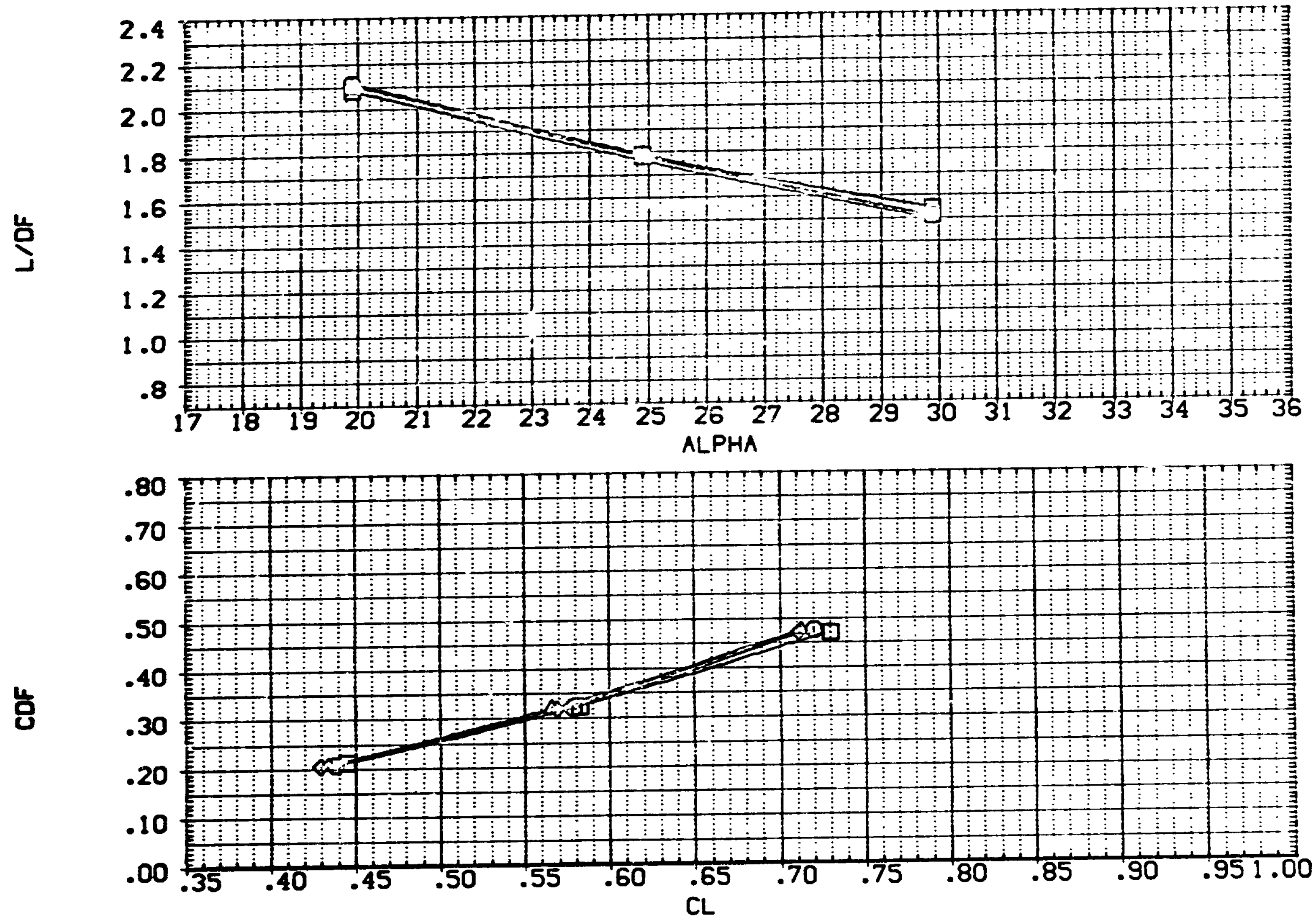


FIGURE 16. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 4.0, ELEVTR= -5)
(A)MACH = 5.93

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(APC09)	○	LA-15.ROCKWELL 0893 ORB V/MOD NOSE V/O OMS(BVVF)	.000	.000	-5.000	-5.000
(APC10)	□	LA-15.ROCKWELL 0893 ORB V/MOD NOSE V/O OMS(BVVF)	.000	1.000	-5.000	-5.000
(APC11)	◇	LA-15.ROCKWELL 0893 ORB V/MOD NOSE V/O OMS(BVVF)	-5.000	.000	-5.000	-5.000
(APC12)	△	LA-15.ROCKWELL 0893 ORB V/MOD NOSE V/O OMS(BVVF)	-5.000	1.000	-5.000	-5.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

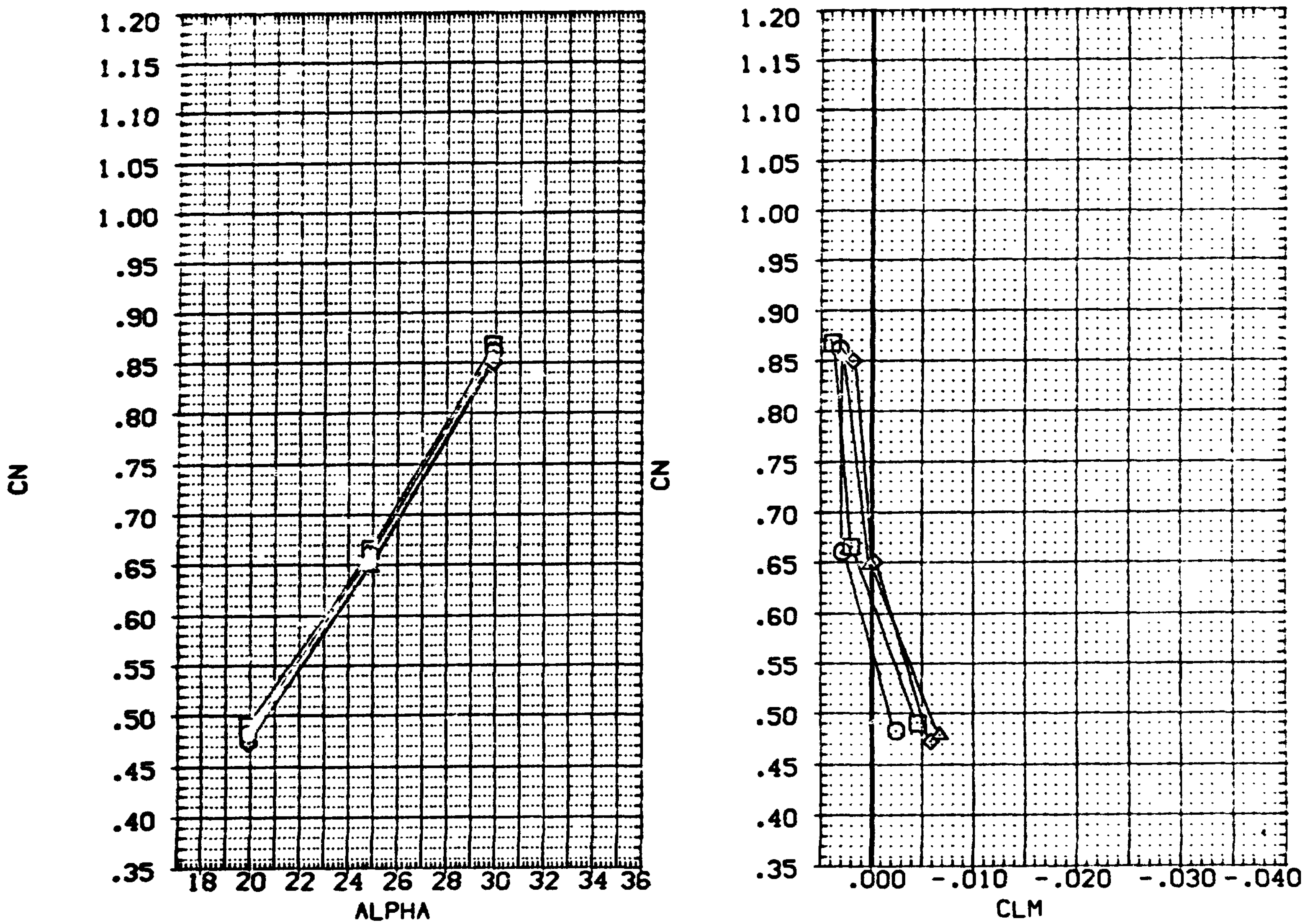


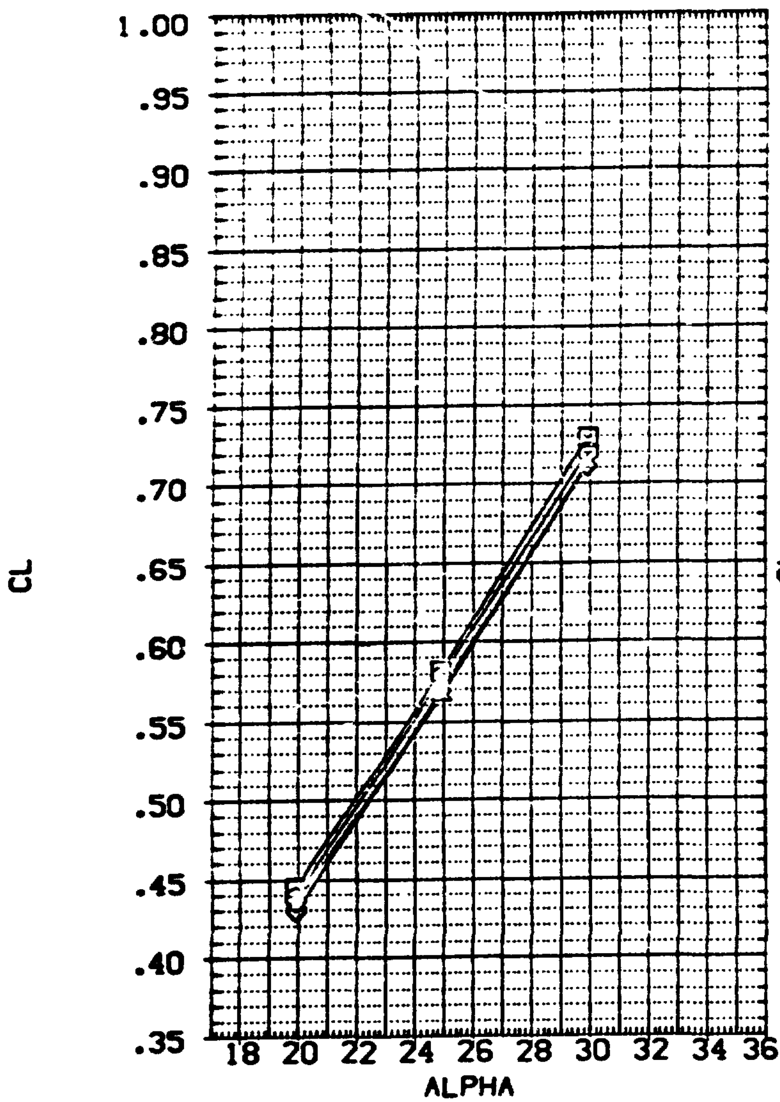
FIGURE 16. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 4.0, ELEVTR= -5)

(A)MACH = 5.93

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(APC009)	○	LA-15.ROCKWELL O898 ORB W/MOD NOSE W/O OMS(BWVF)	.000	.000	-5.000	-5.000
(APC010)	□	LA-15.ROCKWELL O898 ORB W/MOD NOSE W/O OMS(BWVF)	.000	1.000	-5.000	-5.000
(APC011)	◇	LA-15.ROCKWELL O898 ORB W/MOD NOSE W/O OMS(BWVF)	-5.000	.000	-5.000	-5.000
(APC012)	△	LA-15.ROCKWELL O898 ORB W/MOD NOSE W/O OMS(BWVF)	-5.000	1.000	-5.000	-5.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	



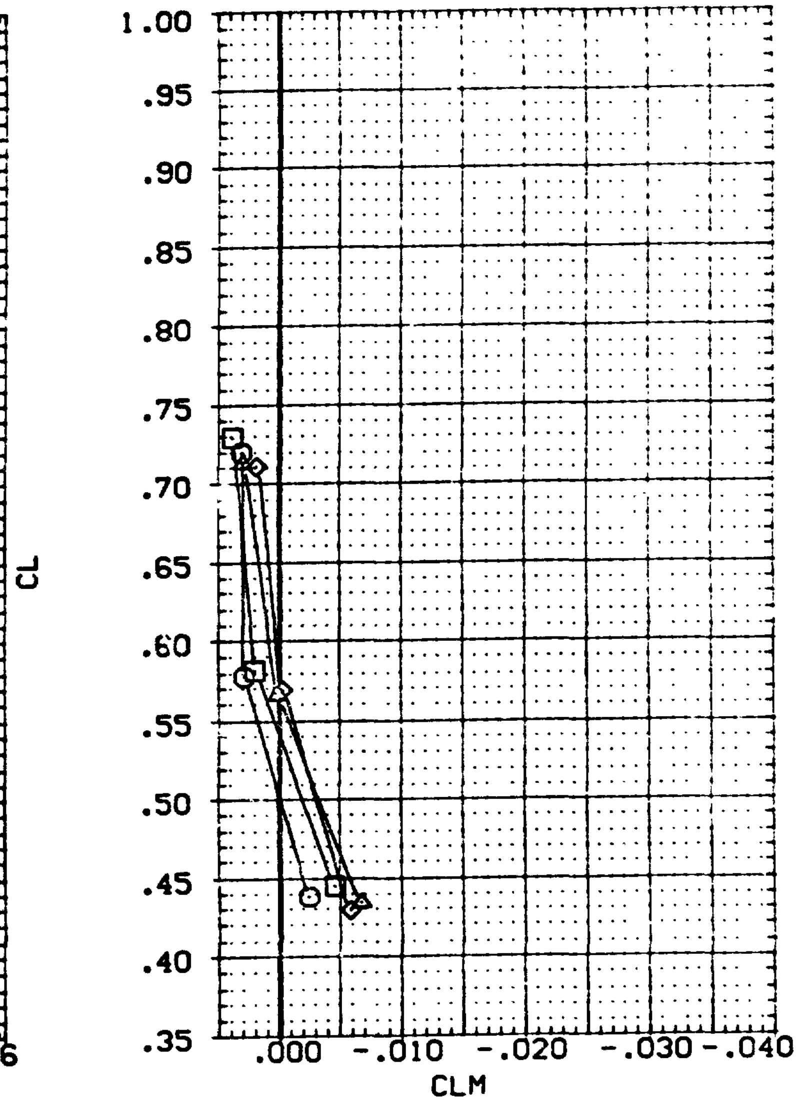


FIGURE 16. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 4.0, ELEVTR= -5)

(A)MACH = 5.93

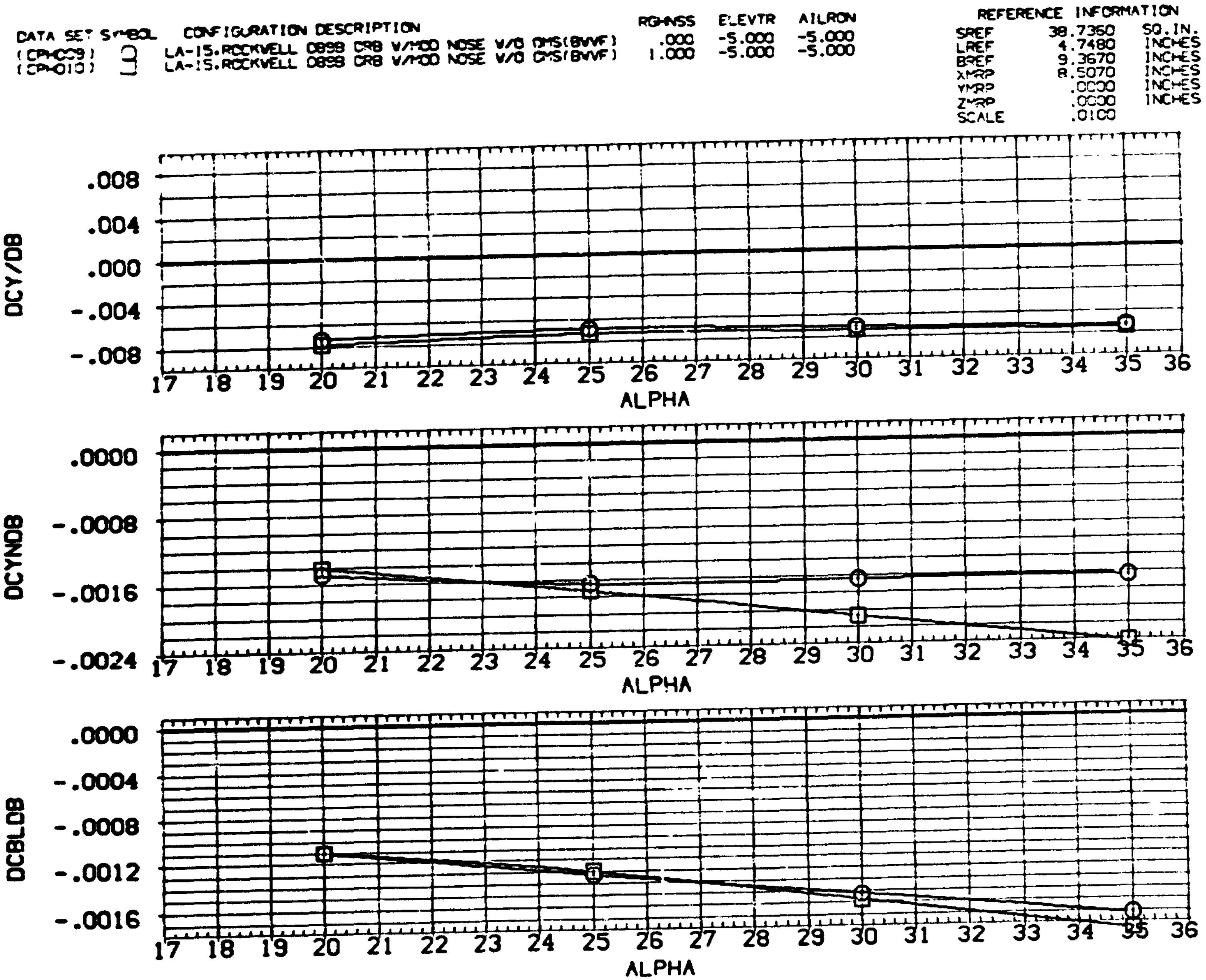


FIGURE 16. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 4.0, ELEVTR= -5)

(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(DPHC09)	○	LA-15.ROCKVELL C899 ORB V/MOD NOSE V/O OMS(BVVF)	.000	.000	-5.000	-5.000
(DPHC10)	□	LA-15.ROCKVELL C899 ORB V/MOD NOSE V/O OMS(BVVF)	.000	1.000	-5.000	-5.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

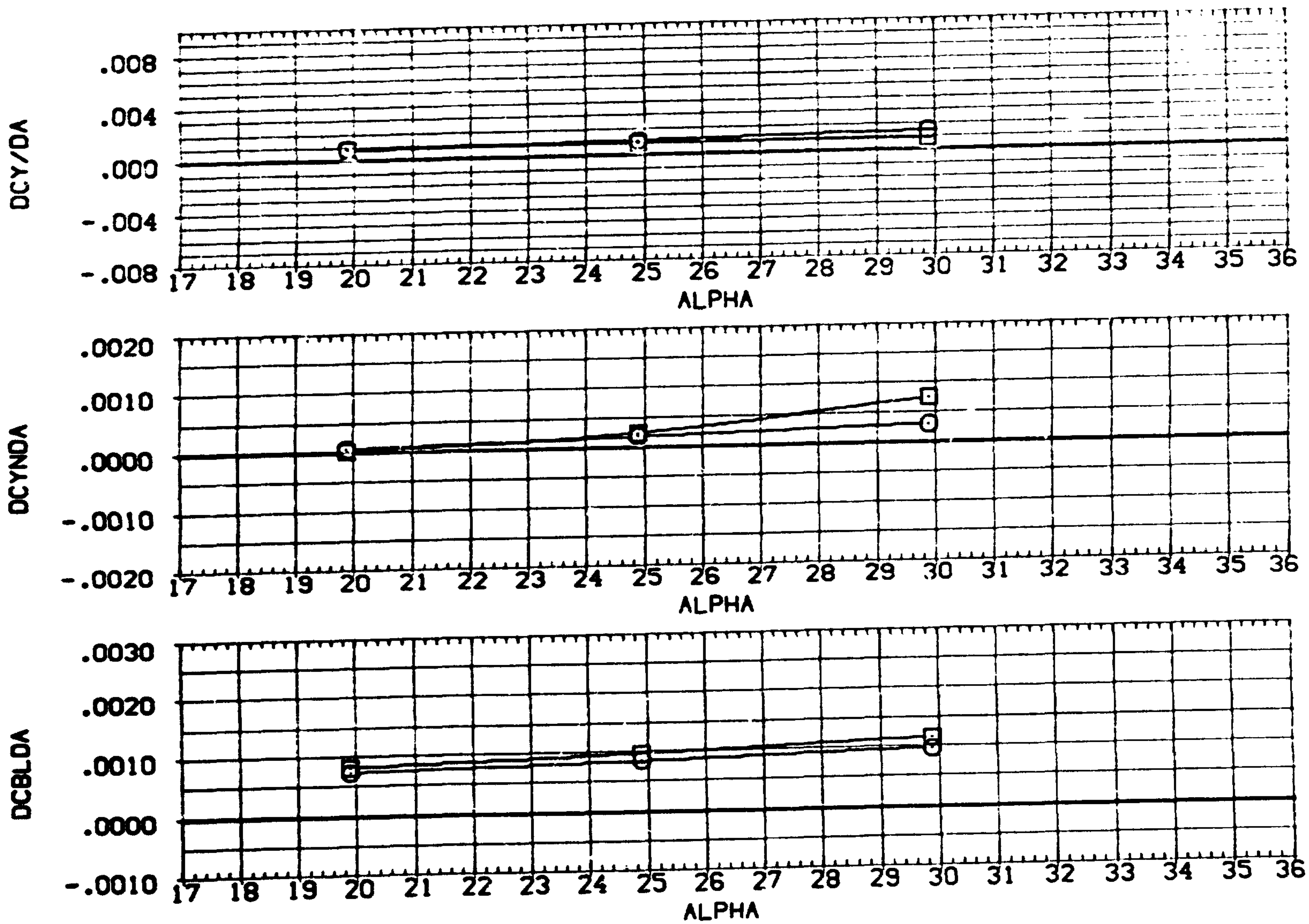
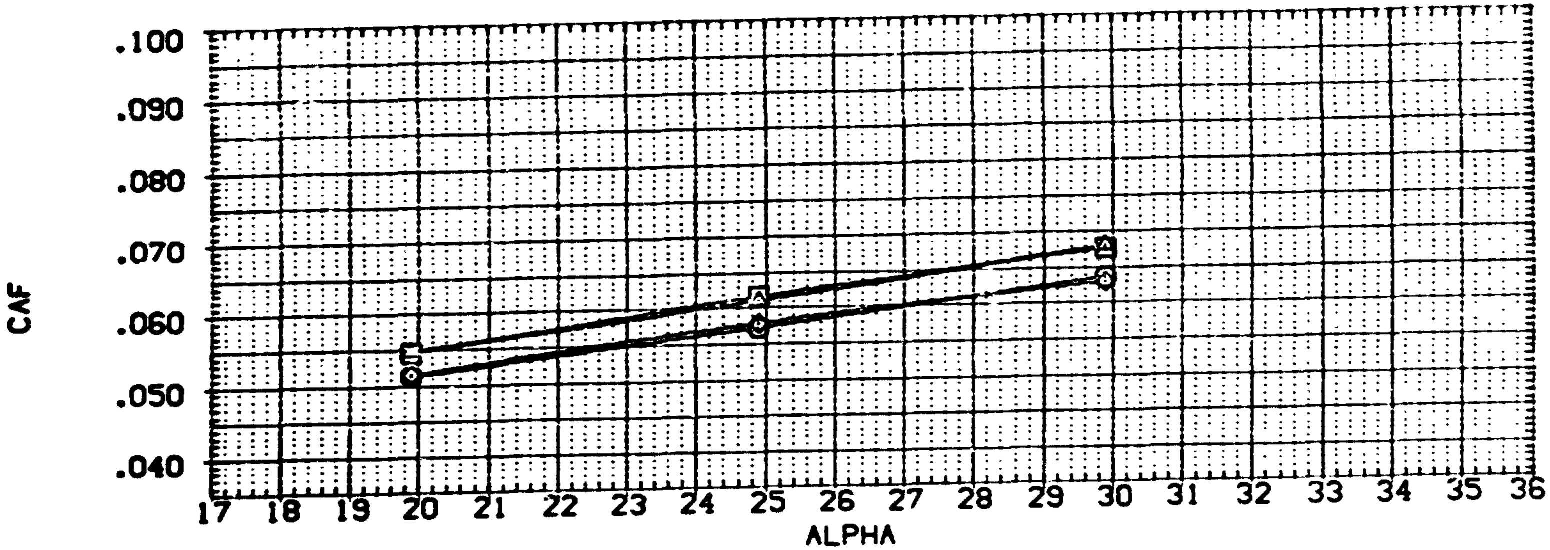


FIGURE 16. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 4.0, ELEVTR= -5)

(A)MACH = 5.93

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(APQ13)	○	LA-15.ROCKWELL OB93 ORB V/MOD NOSE V/O OMS(BVVF)	.000	.000	10.000	4.000
(APQ14)	□	LA-15.ROCKWELL OB93 ORB V/MOD NOSE V/O OMS(BVVF)	.000	1.000	10.000	4.000
(APQ15)	◇	LA-15.ROCKWELL OB93 ORB V/MOD NOSE V/O OMS(BVVF)	-5.000	.000	10.000	4.000
(APQ.5)	△	LA-15.ROCKWELL OB93 ORB V/MOD NOSE V/O OMS(BVVF)	-5.000	1.000	10.000	4.000

REFERENCE INFORMATION		
SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	



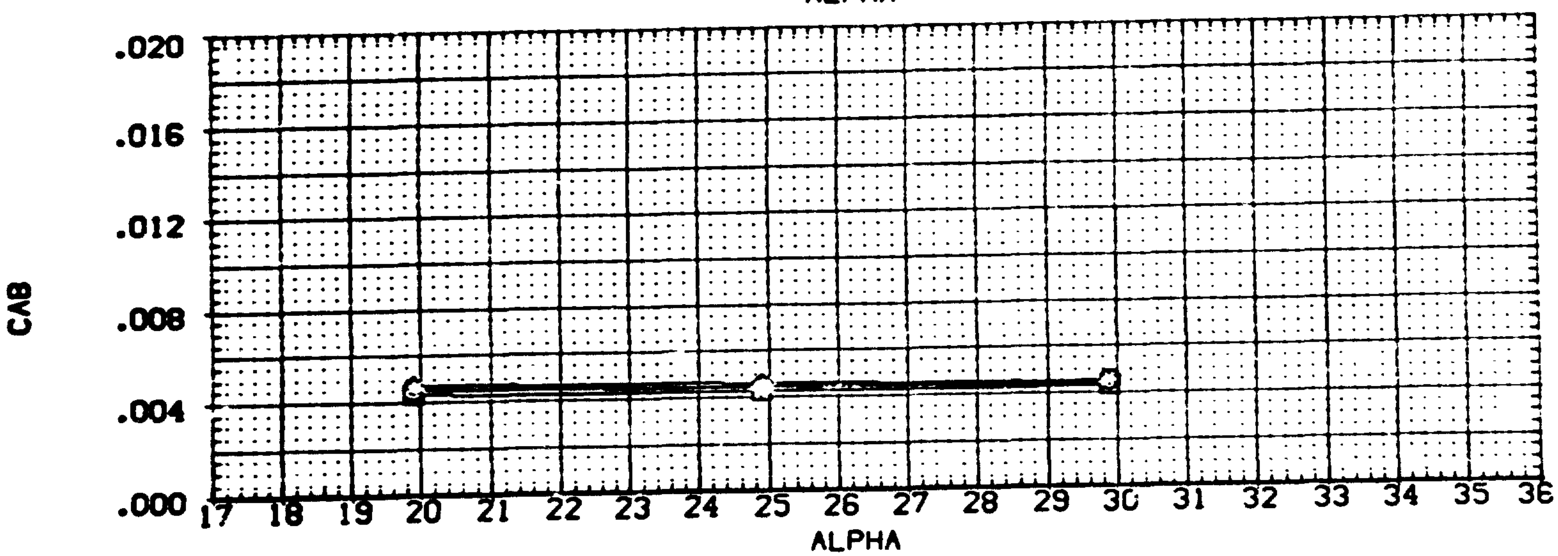


FIGURE 17. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 4.0, ELEVTR= 10)
(A)MACH = 5.95

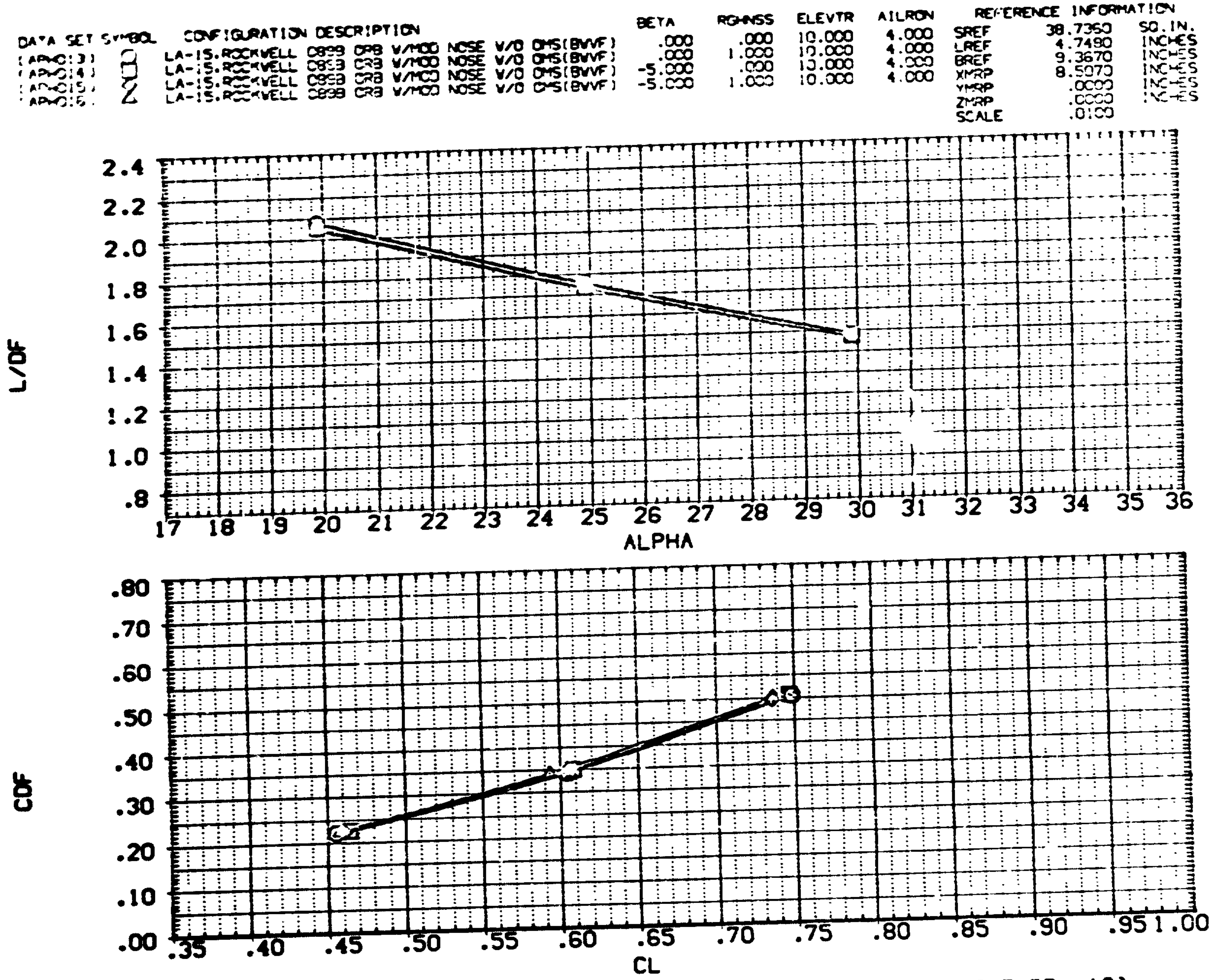


FIGURE 17. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 4.0, ELEVTR= 10)

PAGE 20

(A)MACH = 5.95

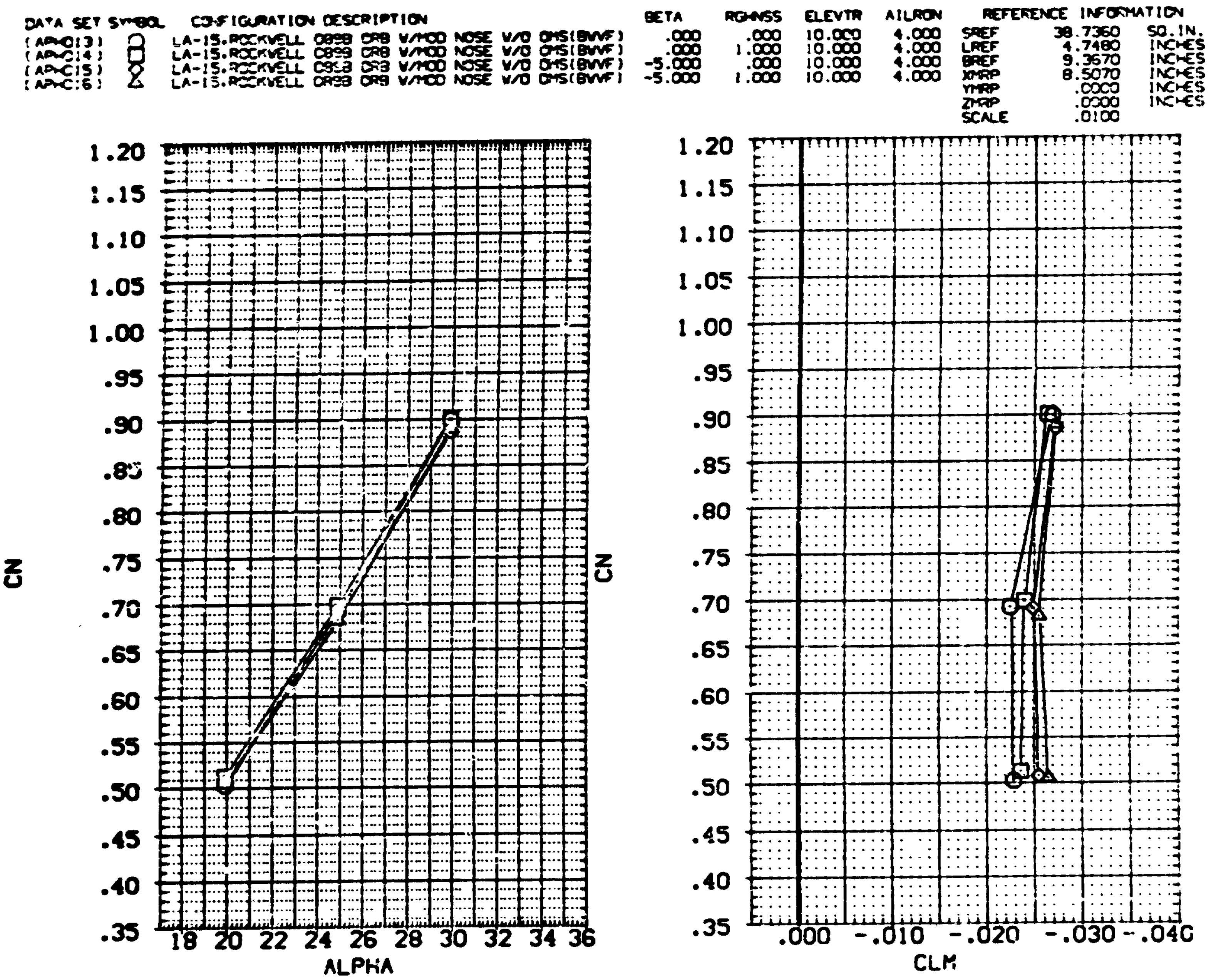


FIGURE 17. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 4.0, ELEVTR= 10)

(A)MACH = 5.95

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(APH013)	○	LA-15.ROCKWELL 0898 CRB V/MOD NOSE V/O OMS(BVVF)	.000	.000	10.000	4.000
(APHC14)	□	LA-15.ROCKWELL 0898 CRB V/MOD NOSE V/O OMS(BVVF)	.000	1.000	10.000	4.000
(APHC15)	◇	LA-15.ROCKWELL 0898 CRB V/MOD NOSE V/O OMS(BVVF)	-5.000	.000	10.000	4.000
(APHC16)	△	LA-15.ROCKWELL 0898 CRB V/MOD NOSE V/O OMS(BVVF)	-5.000	1.000	10.000	4.000

REFERENCE INFORMATION		
SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

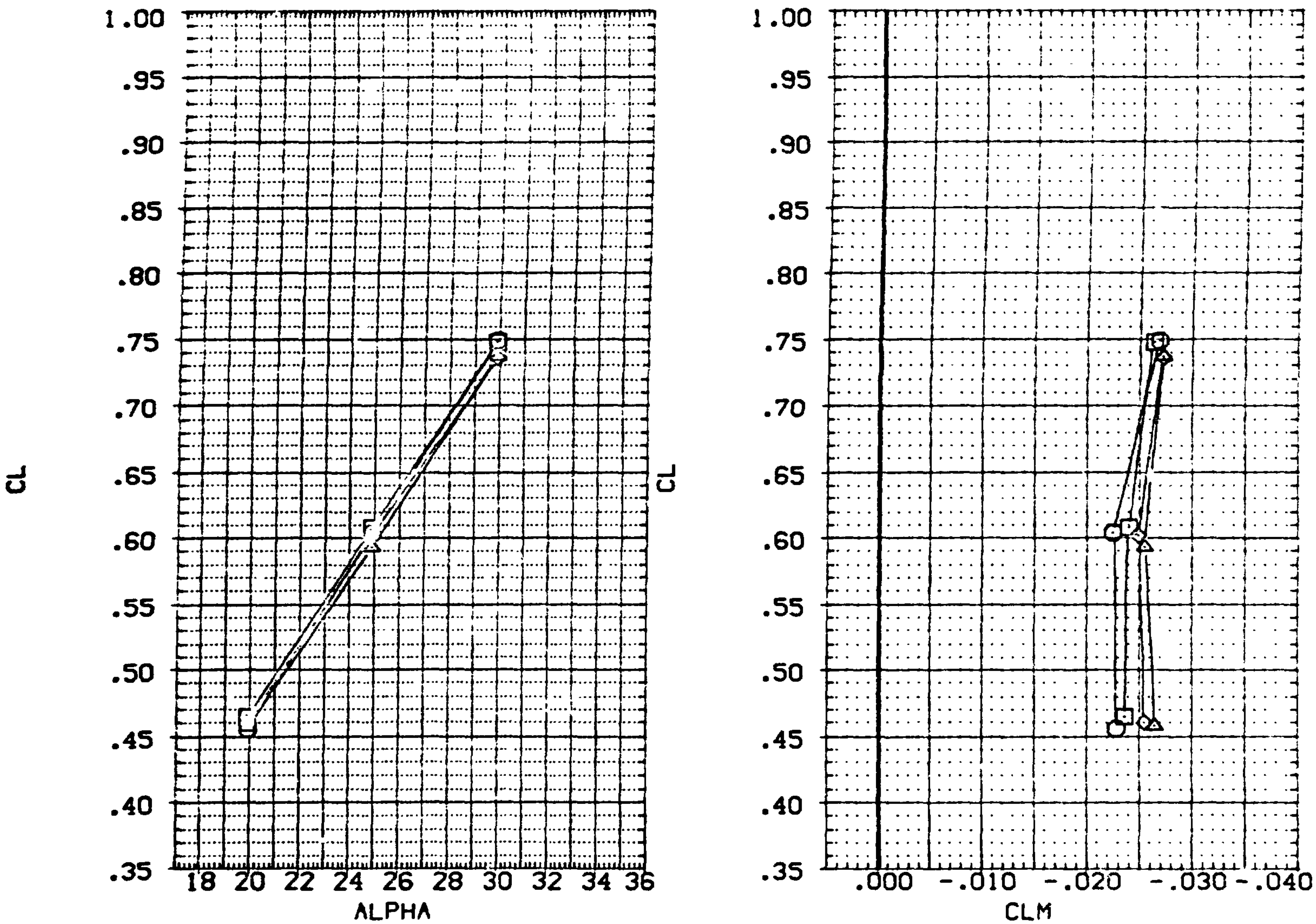


FIGURE 17. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 4.0, ELEVTR= 10)

(A)MACH = 5.95

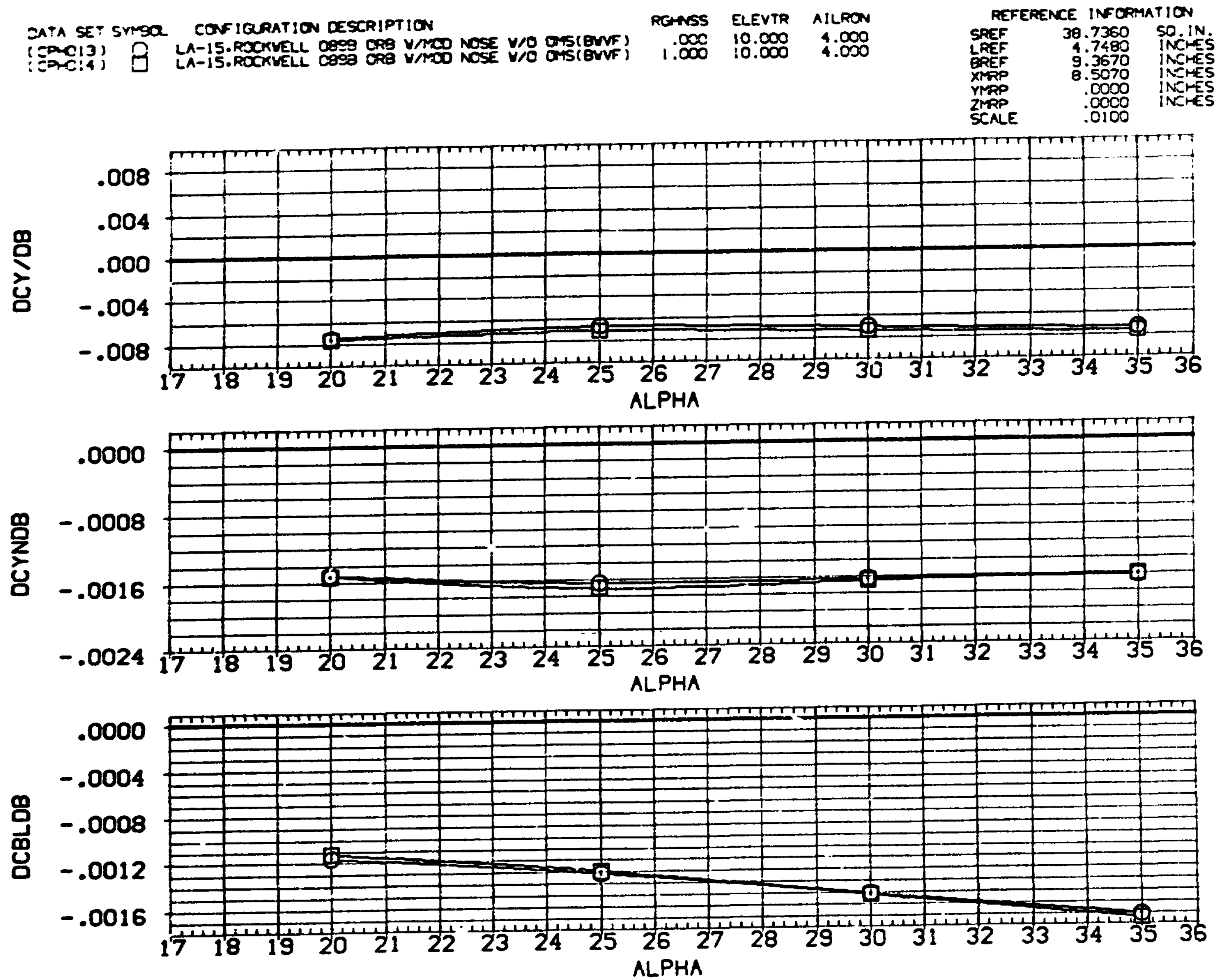


FIGURE 17. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 4.0, ELEVTR= 10)
(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(DPHC13)	☐	LA-15,ROCKWELL 0893 ORB W/MOD NOSE W/O OMS(BVVF)	.000	.000	10.000	4.000
(DPHC14)	☐	LA-15,ROCKWELL 0893 ORB W/MOD NOSE W/O OMS(BVVF)	.000	1.000	10.000	4.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

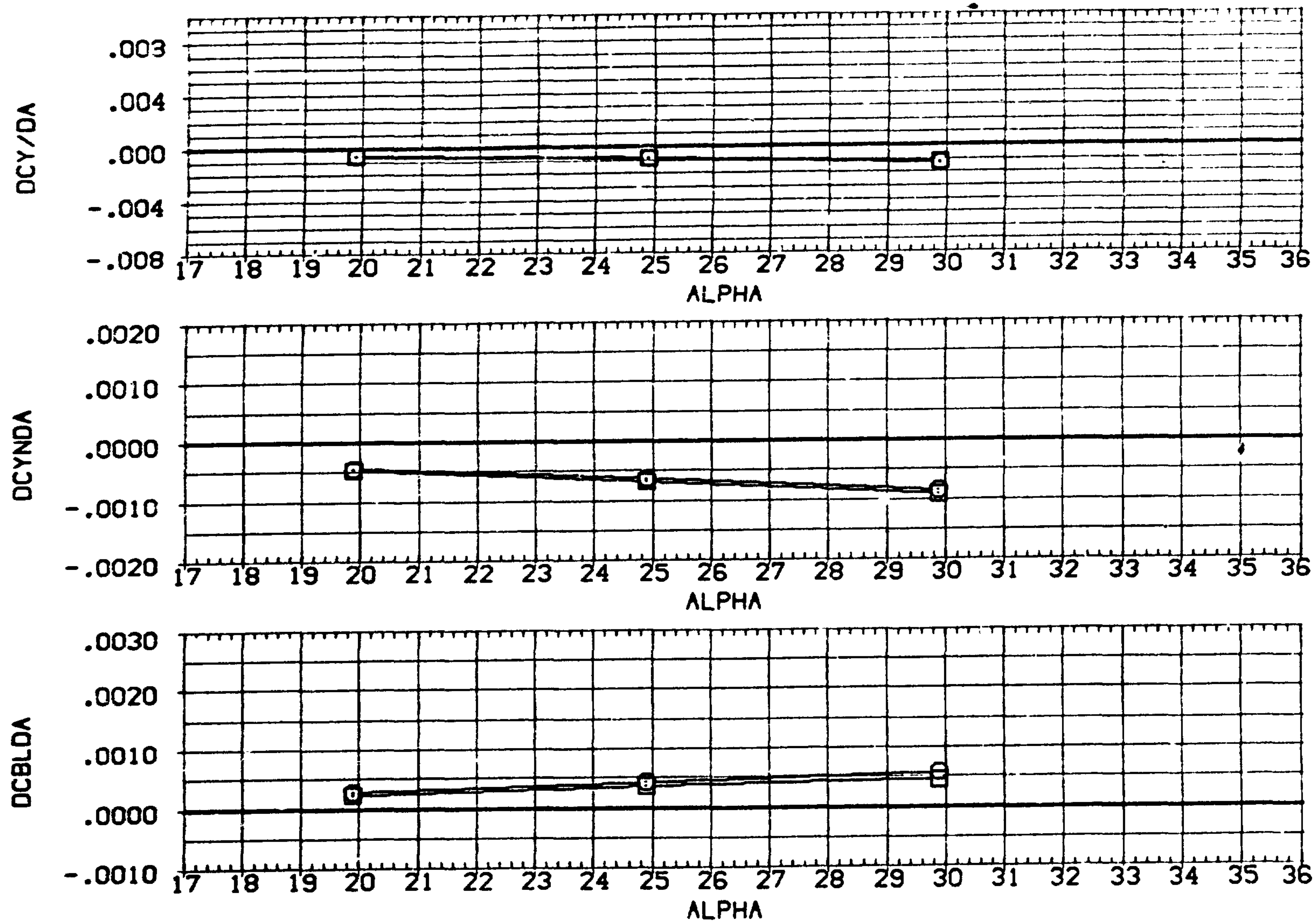


FIGURE 17. EFFECT OF ROUGHNESS ON AERO. PARAMETERS (RN/L= 4.0, ELEVTR= 10)

(A)MACH = 5.95

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	RN/L	ELEVTR	AILRON	RETA
(APHC01)	○	LA-15.ROCKWELL 0898 ORB W/MOD NOSE W/O OMS(BWVF)	9.400	-5.000	-5.000	.000
(APHC09)	□	LA-15.ROCKWELL 0898 ORB W/MOD NOSE W/O OMS(BWVF)	4.000	-5.000	-5.000	.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

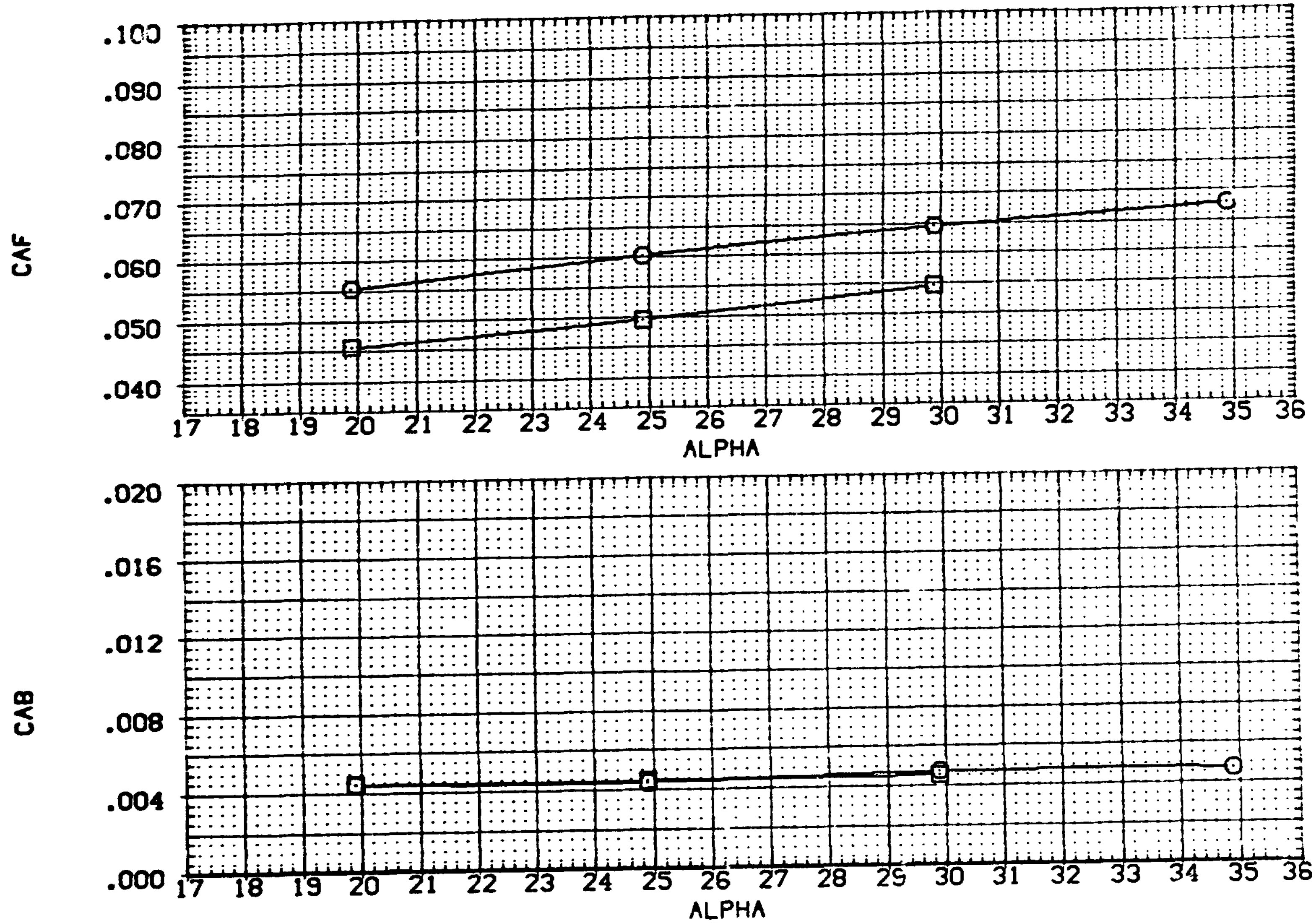


FIGURE 18. EFFECT OF REYNOLDS NO. ON AERO. PARAMETERS W/O ROUGHNESS (ELEVTR= -5)

(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	RN/L	ELEVTR	AILRON	BETA
(APHC01)	○	LA-15,ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BVVF)	9.400	-5.000	-5.000	.000
(APHC09)	□	LA-15,ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BVVF)	4.000	-5.000	-5.000	.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

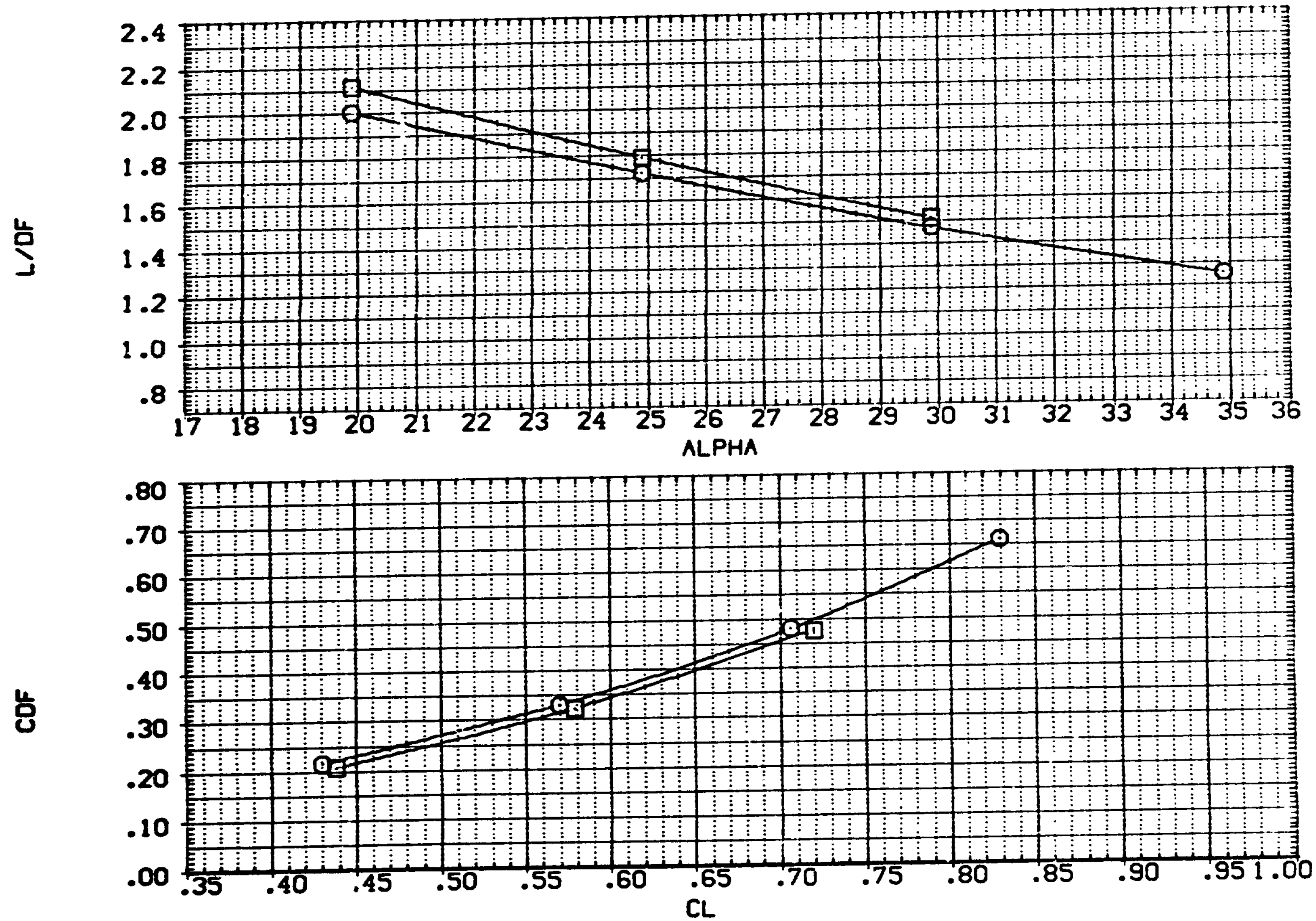


FIGURE 18. EFFECT OF REYNOLDS NO. ON AERO. PARAMETERS W/O ROUGHNESS (ELEVTR= -5)
(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	RN/L	ELEVTR	AILRON	BETA
(APHC01)	○	LA-15,ROCKWELL C899 ORB W/MOD NOSE W/O OMS(BVVF)	9.400	-5.000	-5.000	.000
(APHC09)	□	LA-15,ROCKWELL C899 ORB W/MOD NOSE W/O OMS(BVVF)	4.000	-5.000	-5.000	.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

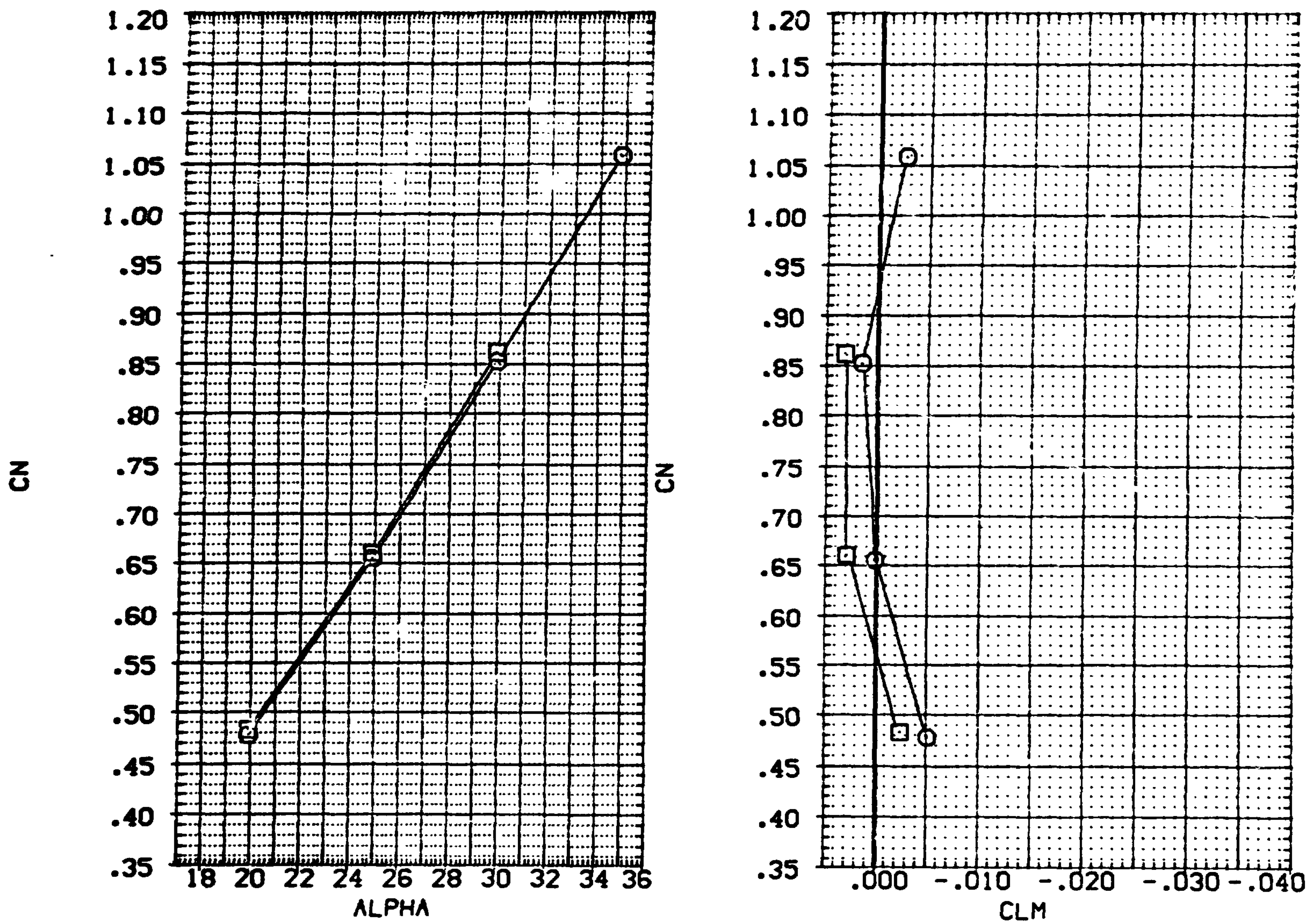


FIGURE 18. EFFECT OF REYNOLDS NO. ON AERO. PARAMETERS W/O ROUGHNESS (ELEVTR= -5)

(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	RN/L	ELEVTR	AILRON	BETA
(AP-C01)	○	LA-15.ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BVVF)	9.400	-5.000	-5.000	.000
(AP-C09)	□	LA-15.ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BVVF)	4.000	-5.000	-5.000	.000

REFERENCE INFORMATION		
SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

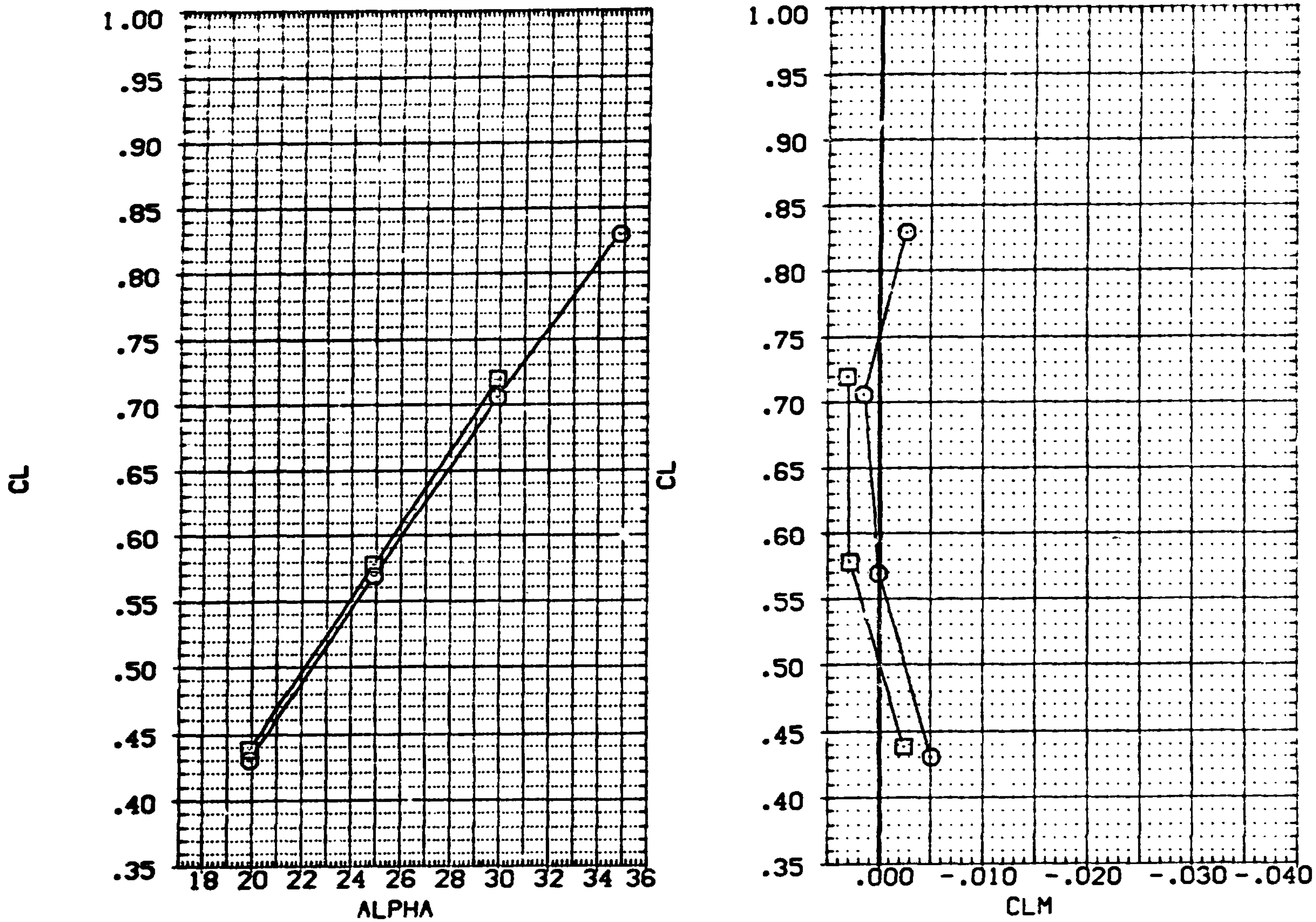


FIGURE 18. EFFECT OF REYNOLDS NO. ON AERO. PARAMETERS W/O ROUGHNESS (ELEVTR= -5)
(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	RN/L	ELEVTR	AILRON	BETA
(CPH001)	○	LA-15,ROCKWELL 0893 ORB W/MOD NOSE W/O OMS(BVVF)	9.400	-5.000	-5.000	
(CPH009)	□	LA-15,ROCKWELL 0893 ORB W/MOD NOSE W/O OMS(BVVF)	4.000	-5.000	-5.000	

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

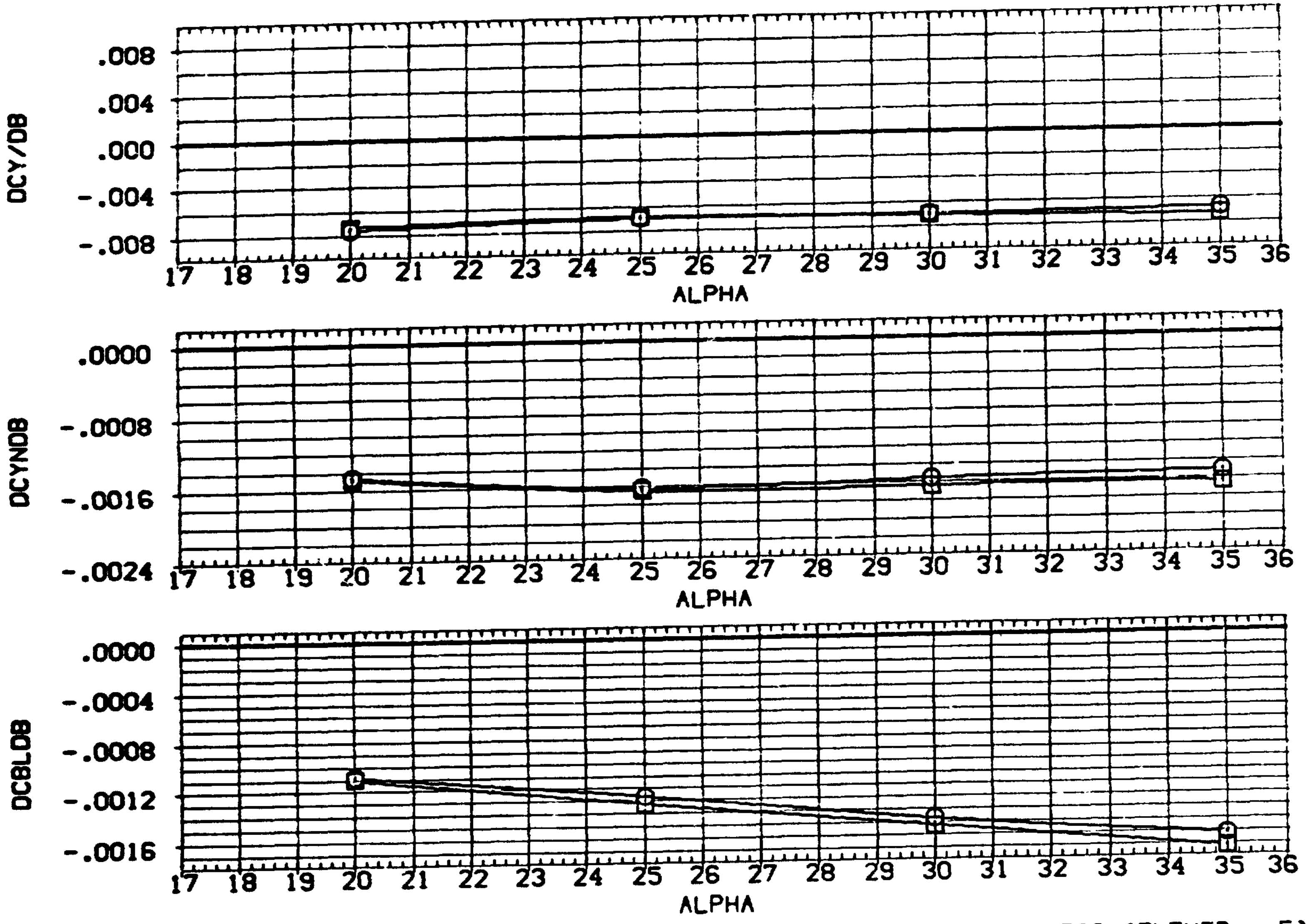


FIGURE 18. EFFECT OF REYNOLDS NO. ON AERO. PARAMETERS W/O ROUGHNESS (ELEVTR= -5)

(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	RN/L	ELEVTR	AILRON	BETA
(DPHOC1)	○	LA-15,ROCKWELL 0899 ORB W/MOD NOSE W/O OMS(BVVF)	9.400	-5.000	-5.000	.000
(DPHOC9)	□	LA-15,ROCKWELL 0893 ORB W/MOD NOSE W/O OMS(BVVF)	4.000	-5.000	-5.000	.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

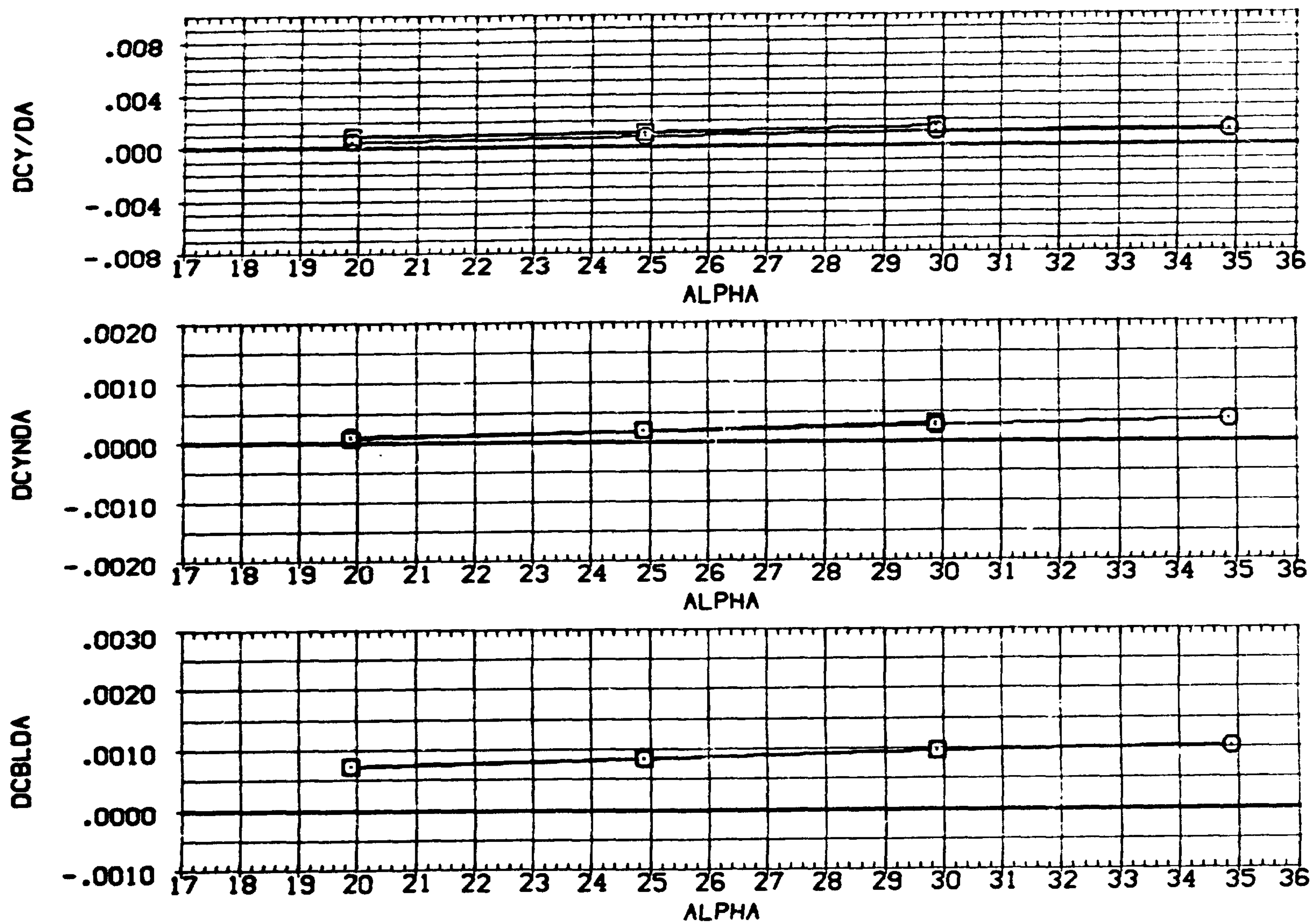


FIGURE 18. EFFECT OF REYNOLDS NO. ON AERO. PARAMETERS W/O ROUGHNESS (ELEVTR= -5)

(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	RN/L	ELEVTR	AILRON	BETA
(APHC05)	○	LA-15.ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BVVF)	9.400	10.000	4.000	.000
(APHO13)	□	LA-15.ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BVVF)	4.000	10.000	4.000	.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

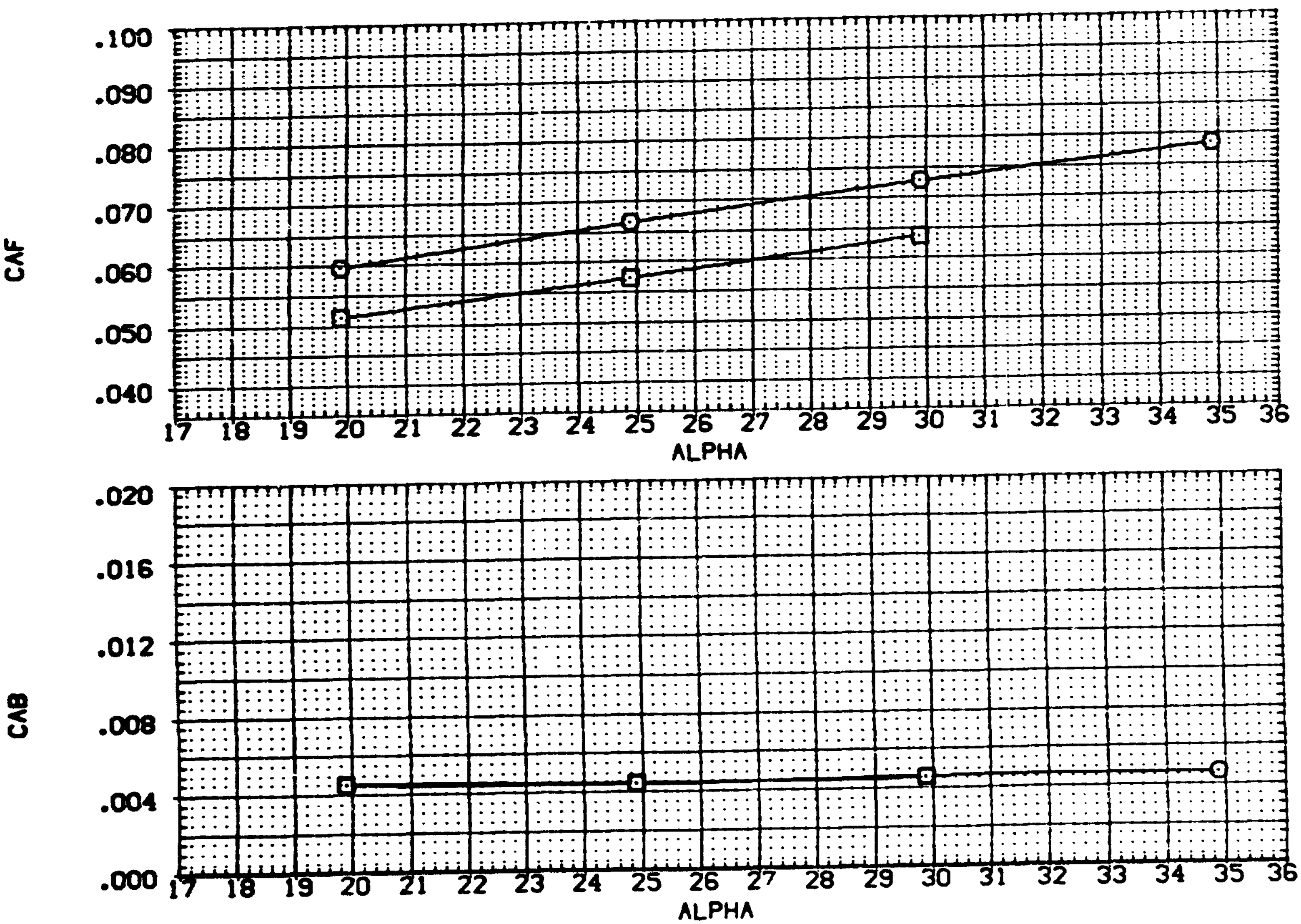


FIGURE 19. EFFECT OF REYNOLDS NO. ON AERO. PARAMETERS W/O ROUGHNESS (ELEVTR= 10)

(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	RN/L	ELEVTR	AILRON	BETA
(APHOC5)	○	LA-15.ROCKWELL 0899 ORB W/MOD NOSE W/O OMS(BV/F)	9.400	10.000	4.000	.000
(APHC13)	□	LA-15.ROCKWELL 0899 ORB W/MOD NOSE W/O OMS(BVVF)	4.000	10.000	4.000	.000

REFERENCE INFORMATION		
SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

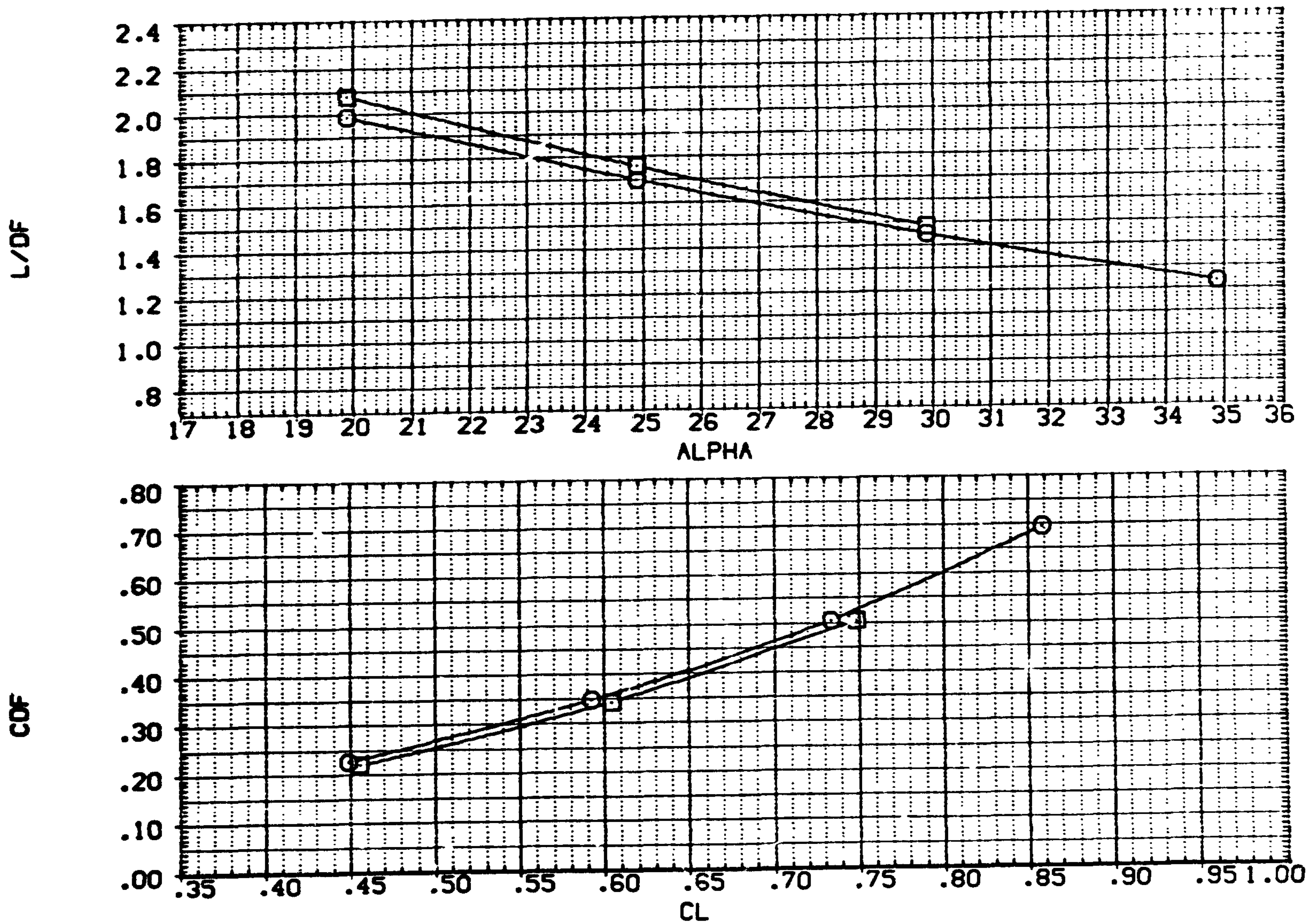


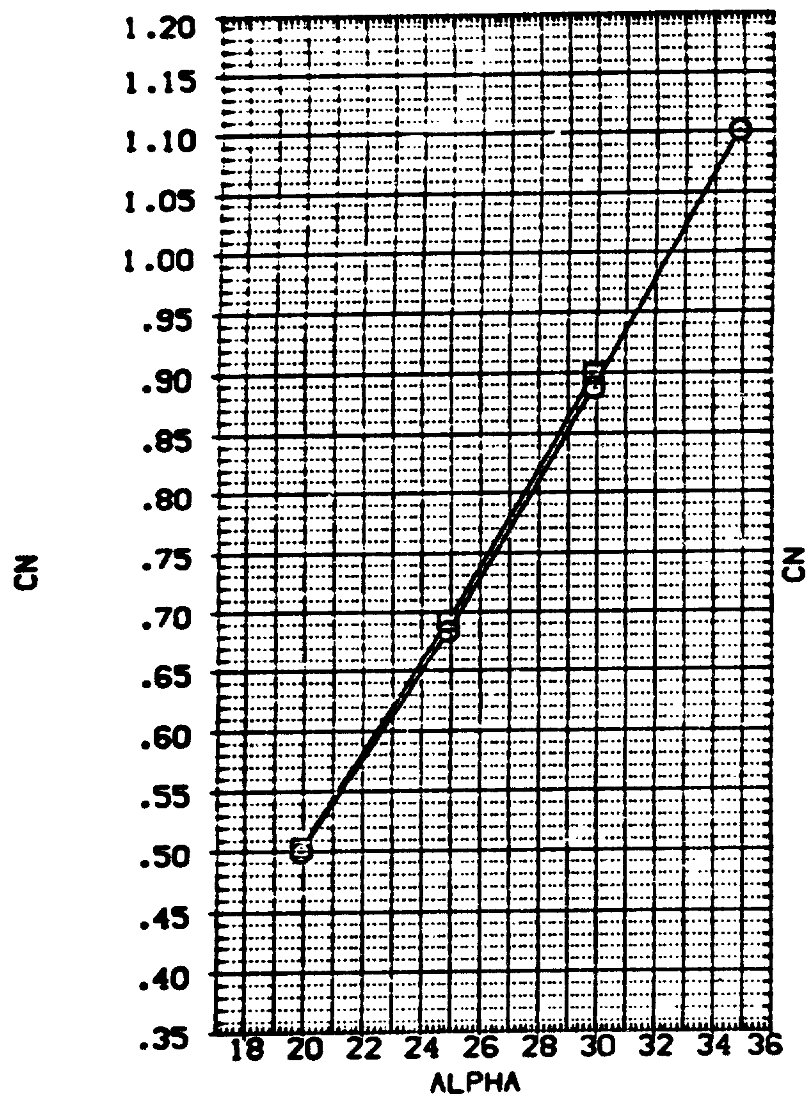
FIGURE 19. EFFECT OF REYNOLDS NO. ON AERO. PARAMETERS W/O ROUGHNESS (ELEVTR= 10)

(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	RN/L	ELEVTR	AILRON	BETA
(APH005)	○	LA-15.ROCKWELL 0899 ORB W/MOD NOSE W/O OMS(BVVF)	9.400	10.000	4.000	.000
(APH013)	□	LA-15.ROCKWELL 0899 ORB W/MOD NOSE W/O OMS(BVVF)	4.000	10.000	4.000	.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	



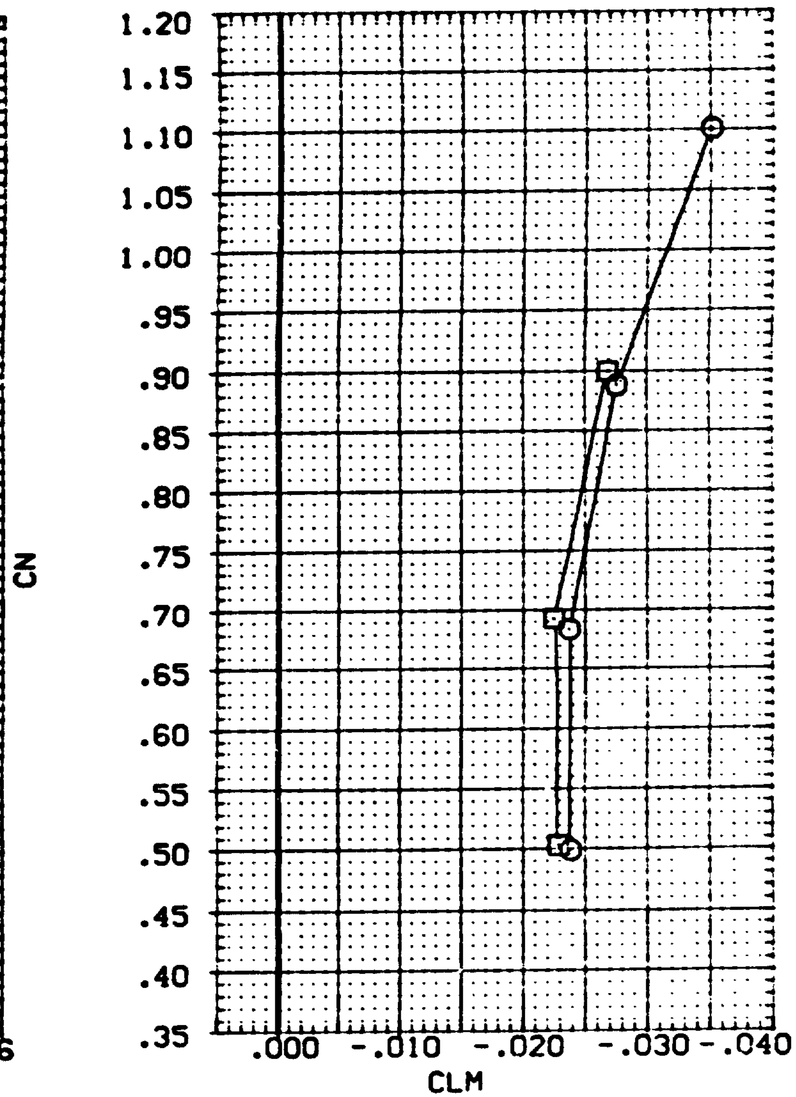


FIGURE 19. EFFECT OF REYNOLDS NO. ON AERO. PARAMETERS W/O ROUGHNESS (ELEVTR= 10)

(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	RN/L	ELEVTR	AILRON	BETA
(APKC05)	○	LA-15,ROCKVELL C893 CR8 W/MOD NOSE W/O OMS(BWVF)	9.400	10.000	4.000	.000
(APKC.3)	□	LA-15,ROCKVELL C893 CR8 W/MOD NOSE W/O OMS(BWVF)	4.000	10.000	4.000	.000

REFERENCE INFORMATION		
SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

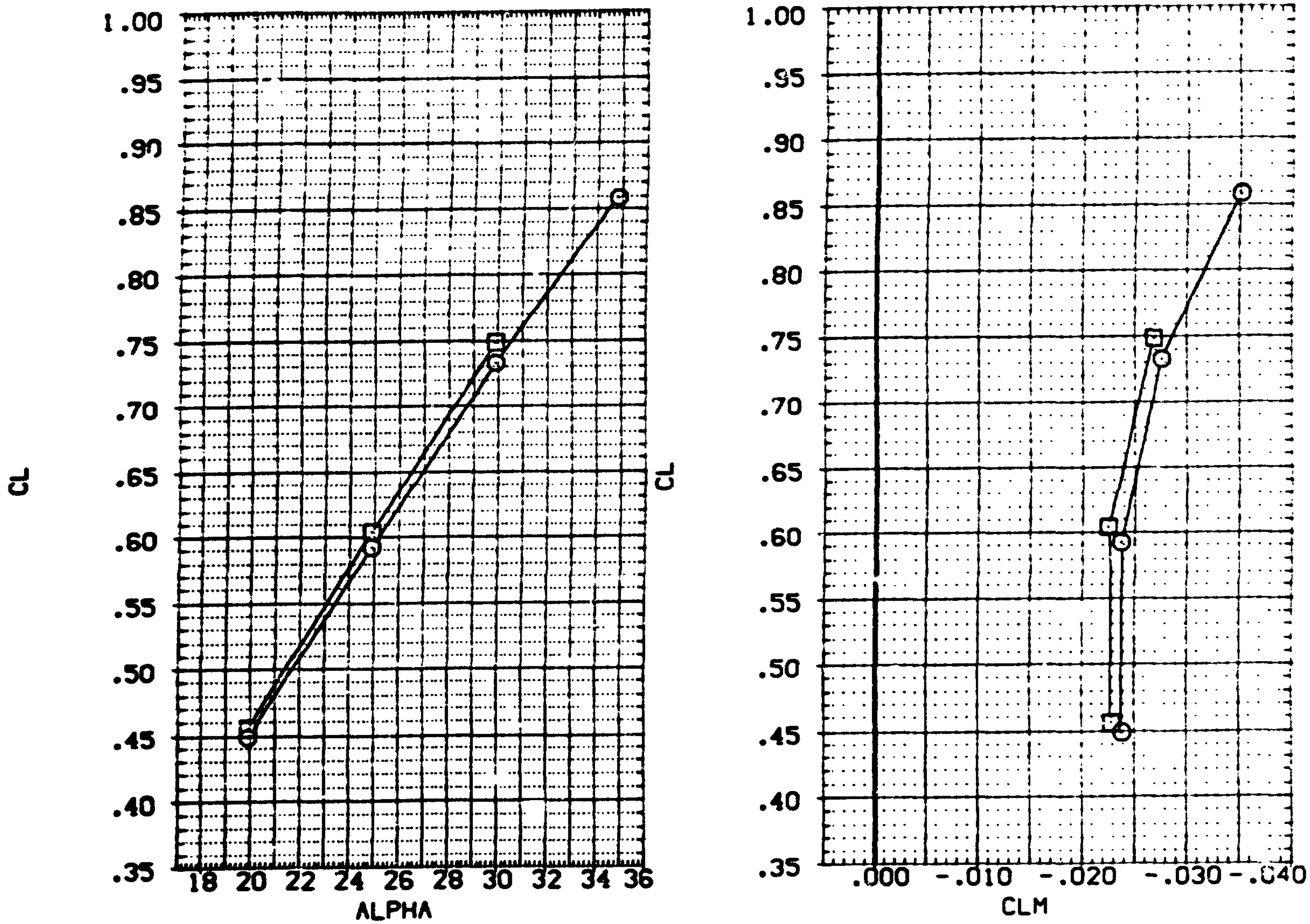


FIGURE 19. EFFECT OF REYNOLDS NO. ON AERO. PARAMETERS W/O ROUGHNESS (ELEVTR= 10)

(A)MACH = 6.00

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	RN/L	ELEVTR	AILRON	BETA
(EPHOC5)	○	LA-15.ROCKWELL 089B ORB W/MOD NOSE W/O OMS(DVVF)	9.400	10.000	4.000	
(EPHC13)	□	LA-15.ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BVVF)	4.000	10.000	4.000	

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

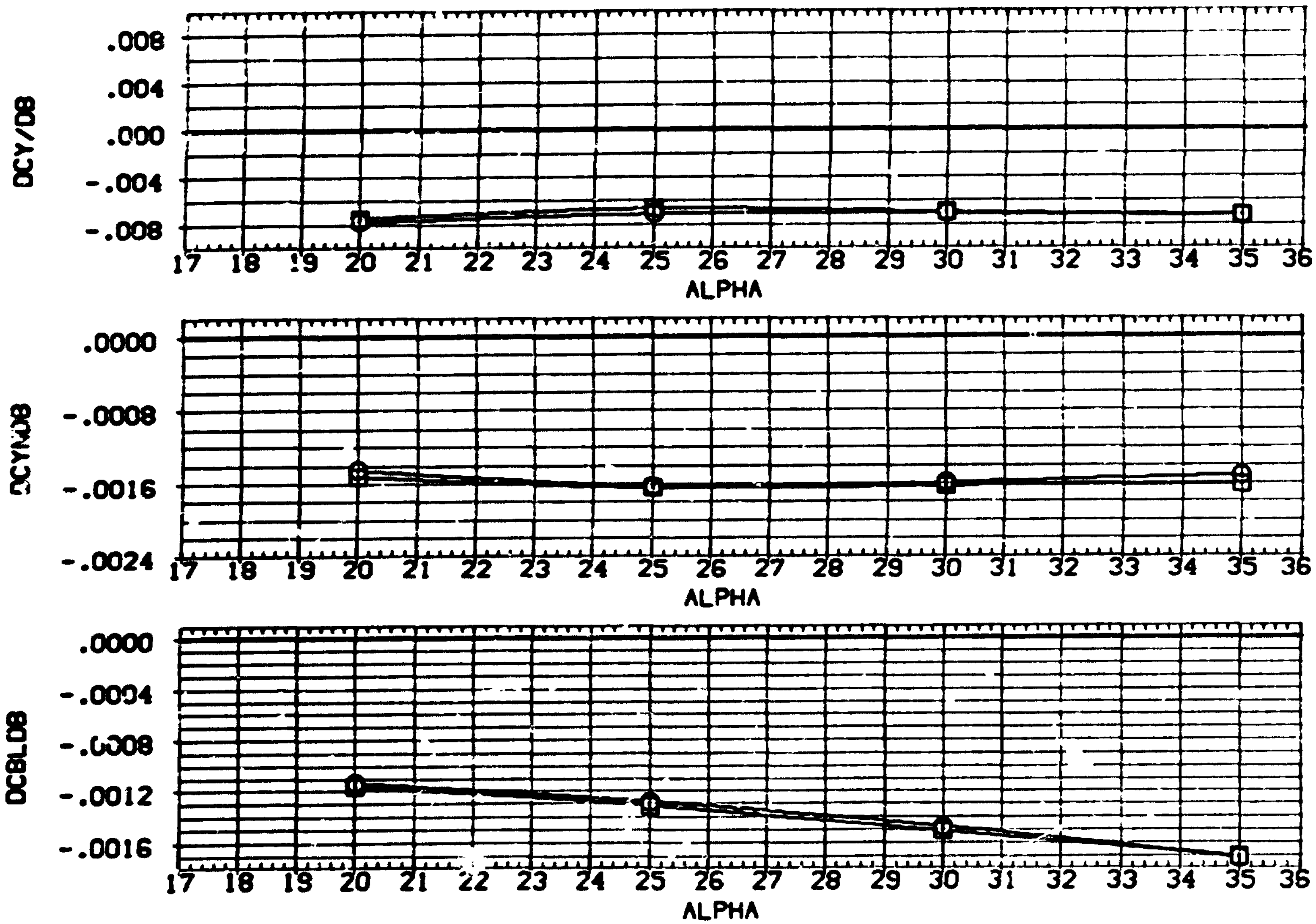


FIGURE 19. EFFECT OF REYNOLDS NO. ON AERO. PARAMETERS W/O ROUGHNESS (ELEVTR= 10)

(A)MACH = 6.00

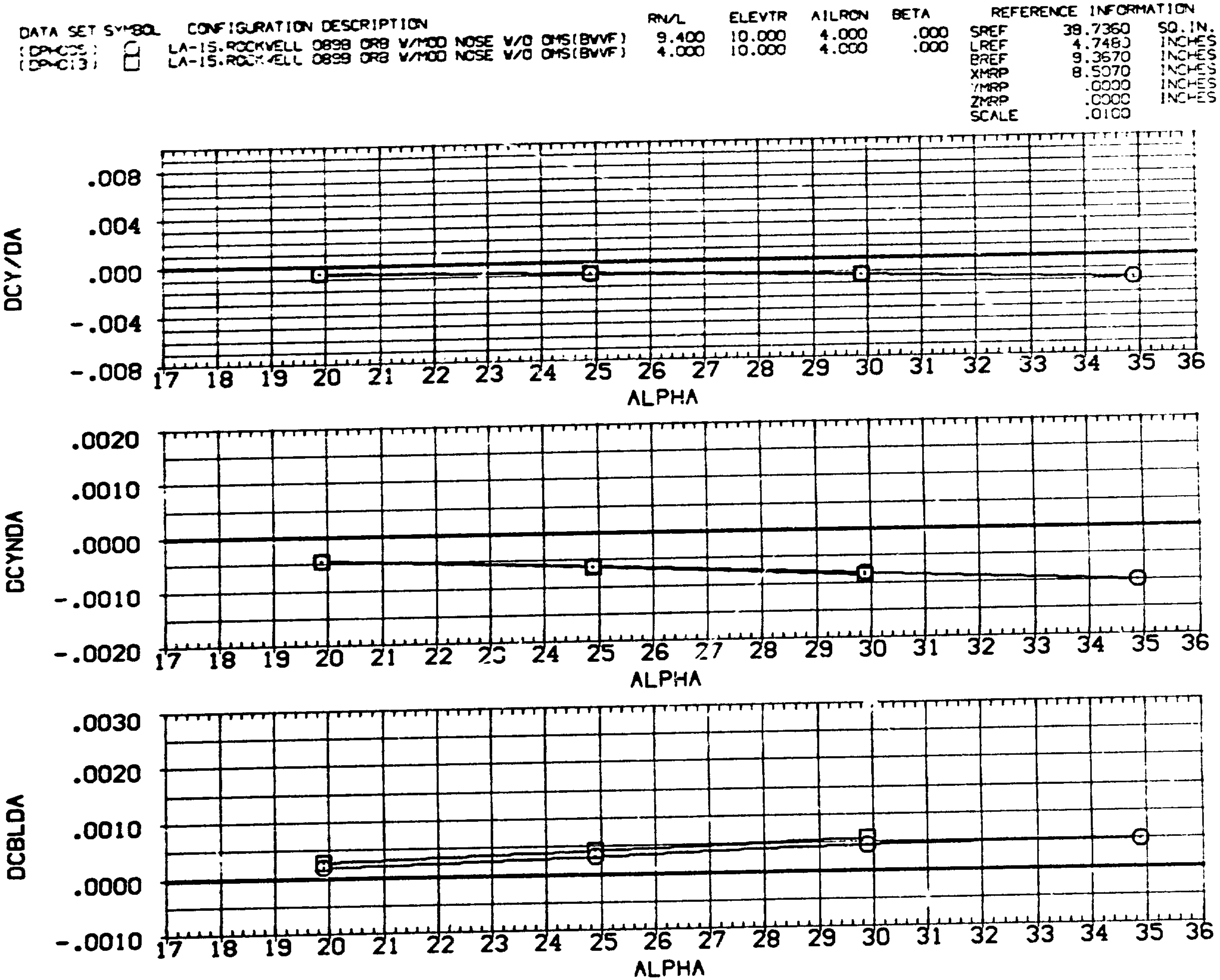


FIGURE 19. EFFECT OF REYNOLDS NO. ON AERO. PARAMETERS W/O ROUGHNESS (ELEVTR= 10)
(A)MACH = 6.00

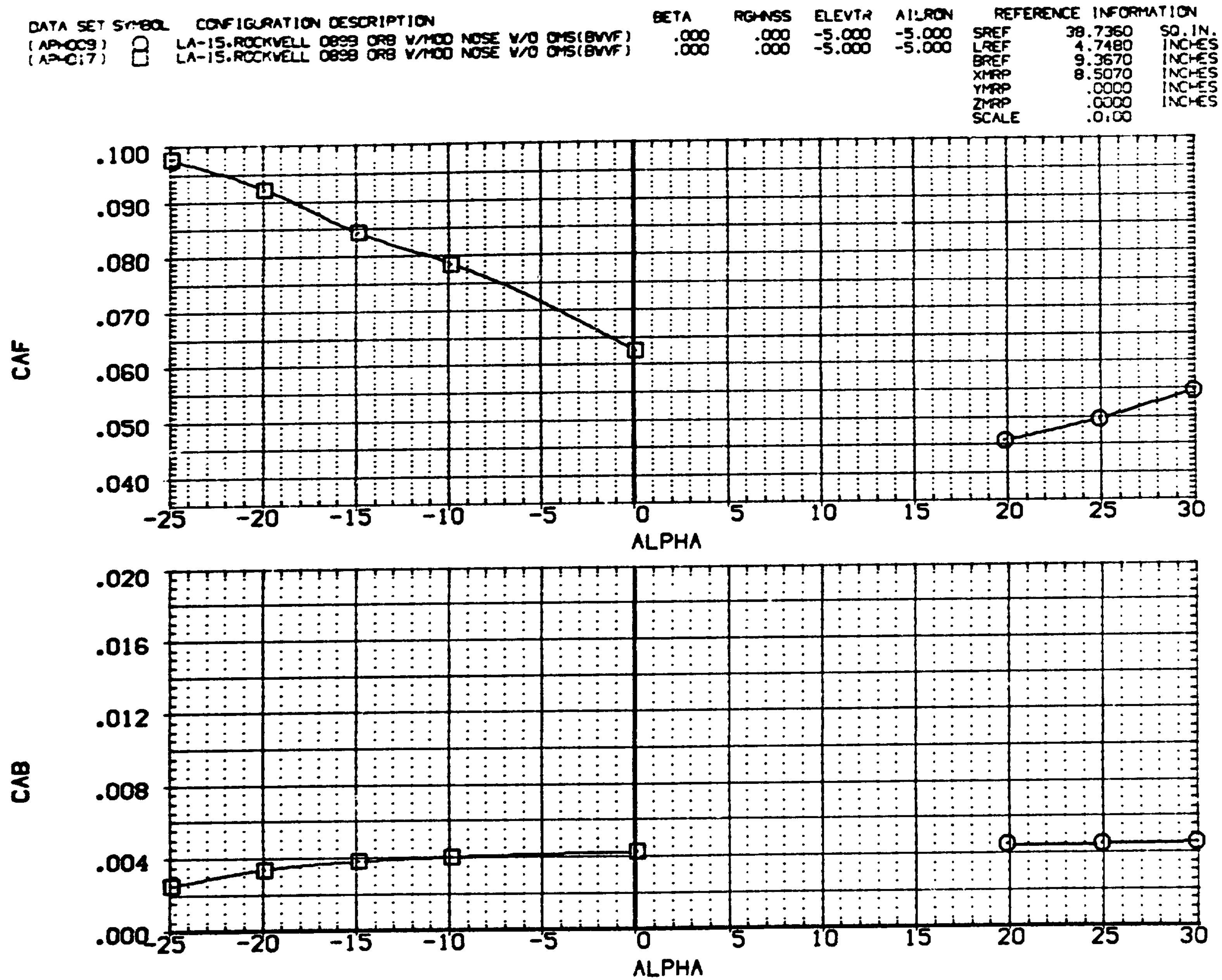


FIGURE 20. EFFECT OF ANGLE OF ATTACK ON AERO. PARAMETERS (ELEVTR = -5)
(A)MACH = 5.93

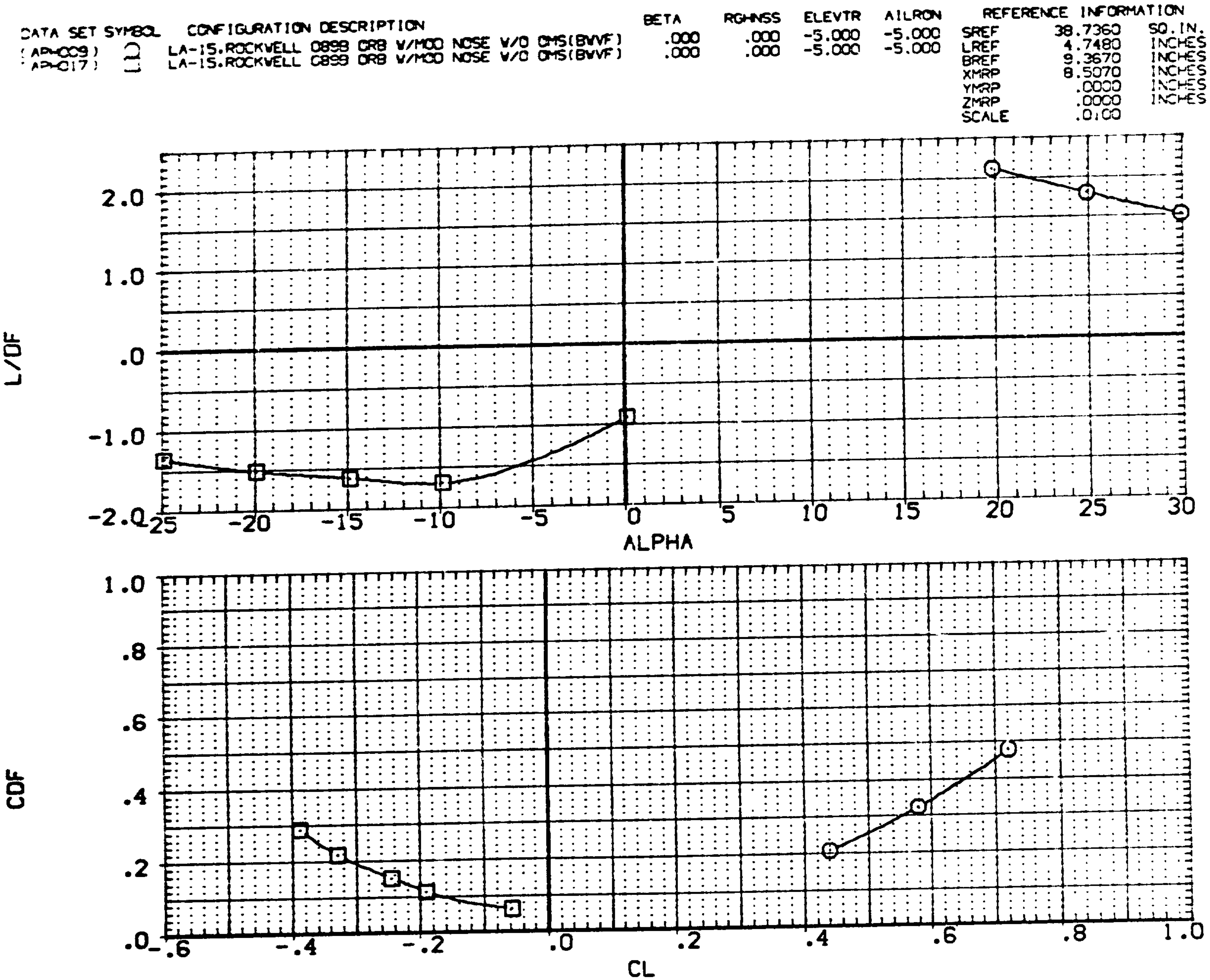


FIGURE 20. EFFECT OF ANGLE OF ATTACK ON AERO. PARAMETERS (ELEVTR = -5)

(A)MACH = 5.93

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(APHC09)	○	LA-15.ROCKWELL 0838 ORB W/MOD NOSE W/O OMS(BWVF)	.000	.000	-5.000	-5.000
(APHC17)	□	LA-15.ROCKWELL 0898 ORB W/MOD NOSE W/O OMS(BWVF)	.000	.000	-5.000	-5.000

REFERENCE INFORMATION		
SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

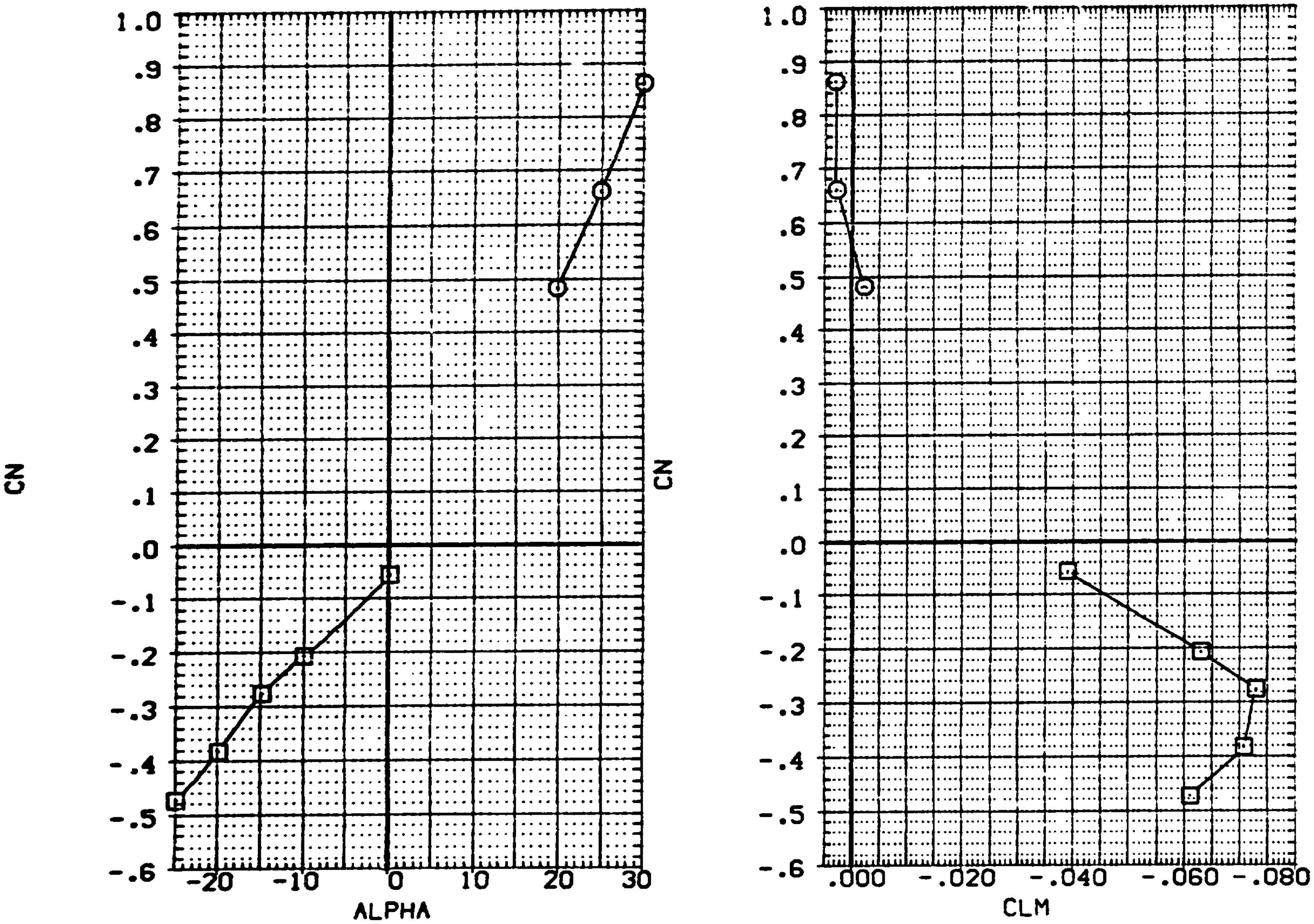


FIGURE 20. EFFECT OF ANGLE OF ATTACK ON AERO. PARAMETERS (ELEVTR = -5)
(A)MACH = 5.93

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(AFH009)	○	LA-15.ROCKWELL 0893 ORB W/MOD NOSE W/O OMS(BWVF)	.000	.000	-5.000	-5.000
(APH017)	□	LA-15.ROCKWELL 0893 ORB W/MOD NOSE W/O OMS(BWVF)	.000	.000	-5.000	-5.000

REFERENCE INFORMATION		
SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

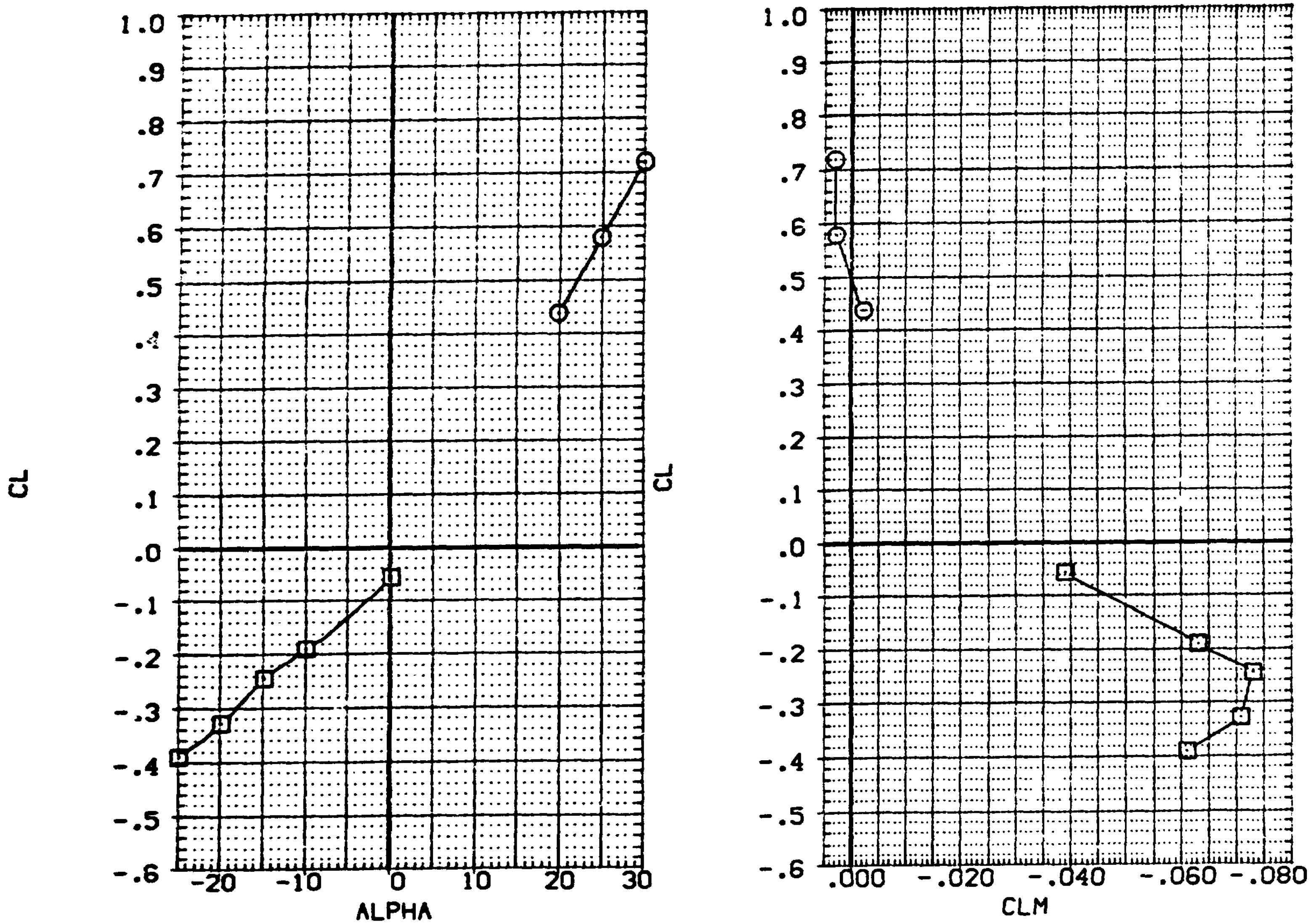


FIGURE 20. EFFECT OF ANGLE OF ATTACK ON AERO. PARAMETERS (ELEVTR = -5)

(A)MACH = 5.93

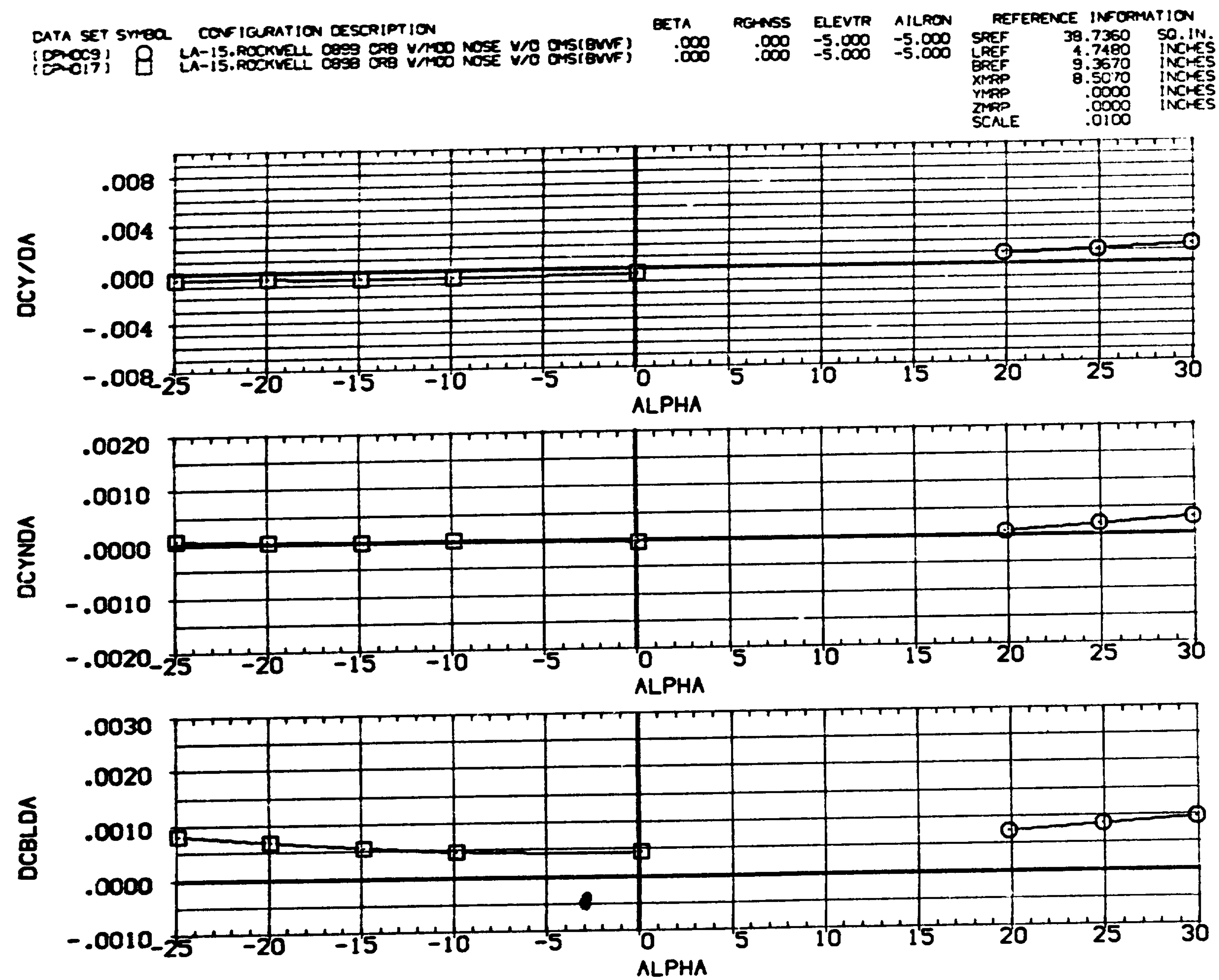


FIGURE 20. EFFECT OF ANGLE OF ATTACK ON AERO. PARAMETERS (ELEVTR = -5)
(A)MACH = 5.93

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(APHO18)	○	LA-15.ROCKWELL 0898 CP9 V/MOD NOSE V/O OMS(BVVF)	.000	.000	-30.000	.000
(APHO19)	□	LA-15.ROCKWELL 0898 CR8 V/MOD NOSE V/O OMS(BVVF)	5.000	.000	-30.000	.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3570	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

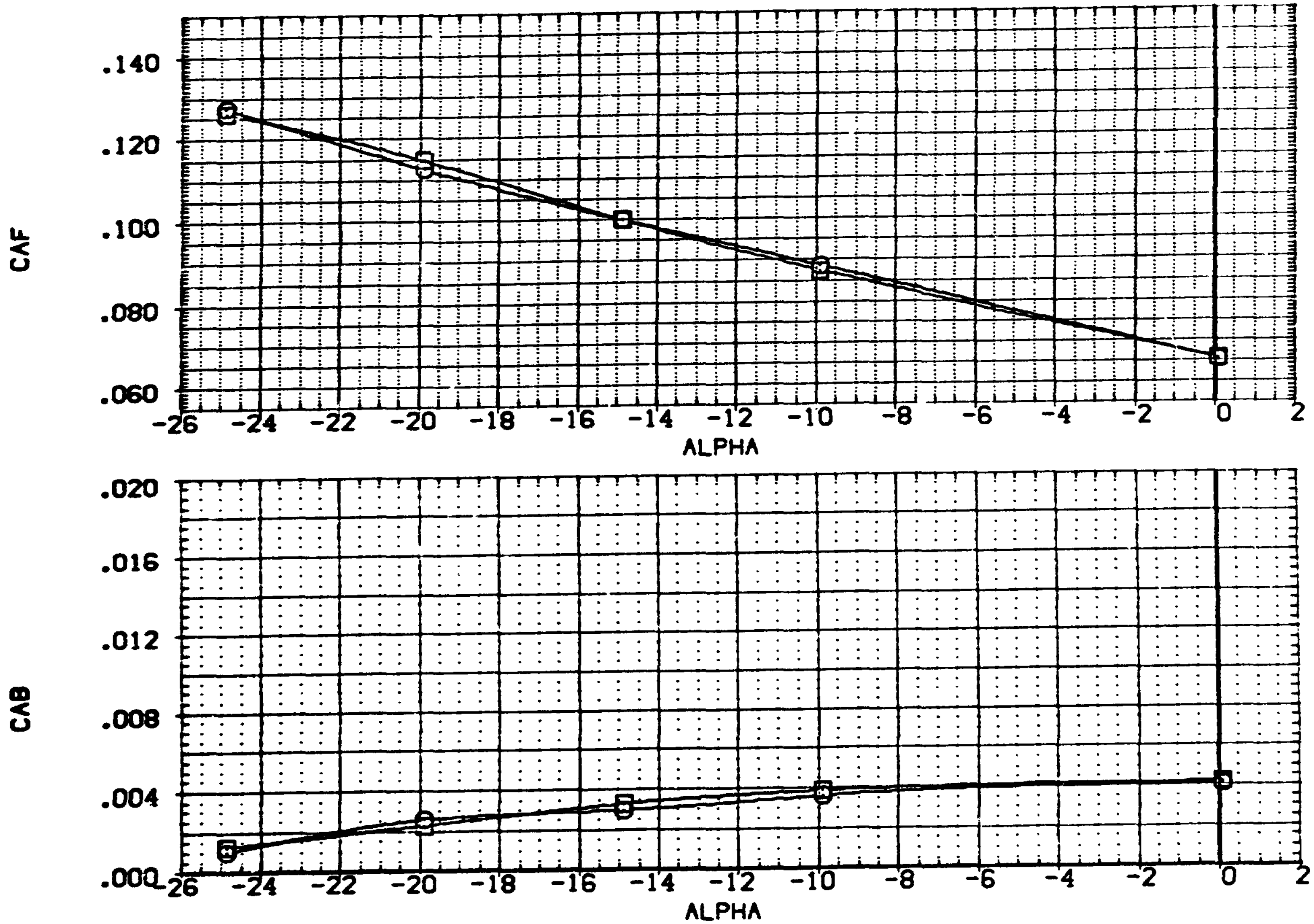


FIGURE 21. EFFECT OF ANGLE OF ATTACK ON AERO. PARAMETERS (ELEVATOR =-30)
(A)MACH = 5.94

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(APHC18)	○	LA-15.ROCKWELL 0898 ORB W/MOD NOSE W/O OMS(BVVF)	.000	.000	-30.000	.000
(APHC19)	□	LA-15.ROCKWELL 0893 ORB W/MOD NOSE W/O OMS(BVVF)	5.000	.000	-30.000	.000

REFERENCE INFORMATION		
SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

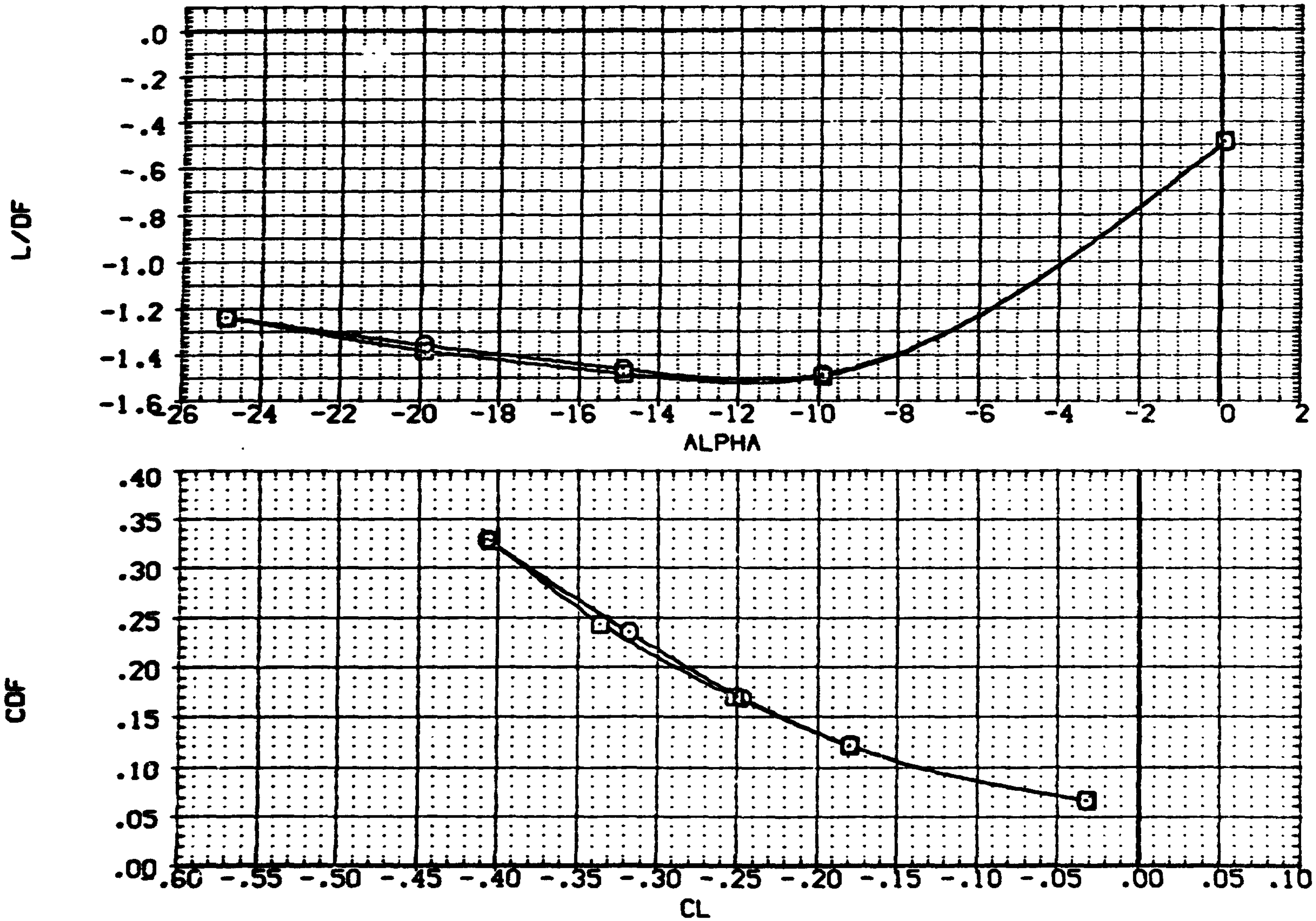


FIGURE 21. EFFECT OF ANGLE OF ATTACK ON AERO. PARAMETERS (ELEVATOR =-30)

(A)MACH = 5.94

DATA SET	SYMBOL	CONFIGURATION DESCRIPTION	BETA	RGHNSS	ELEVTR	AILRON
(APHC18)	○	LA-15, ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BWVF)	.000	.000	-30.000	.000
(APHC19)	□	LA-15, ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BWVF)	5.000	.000	-30.000	.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

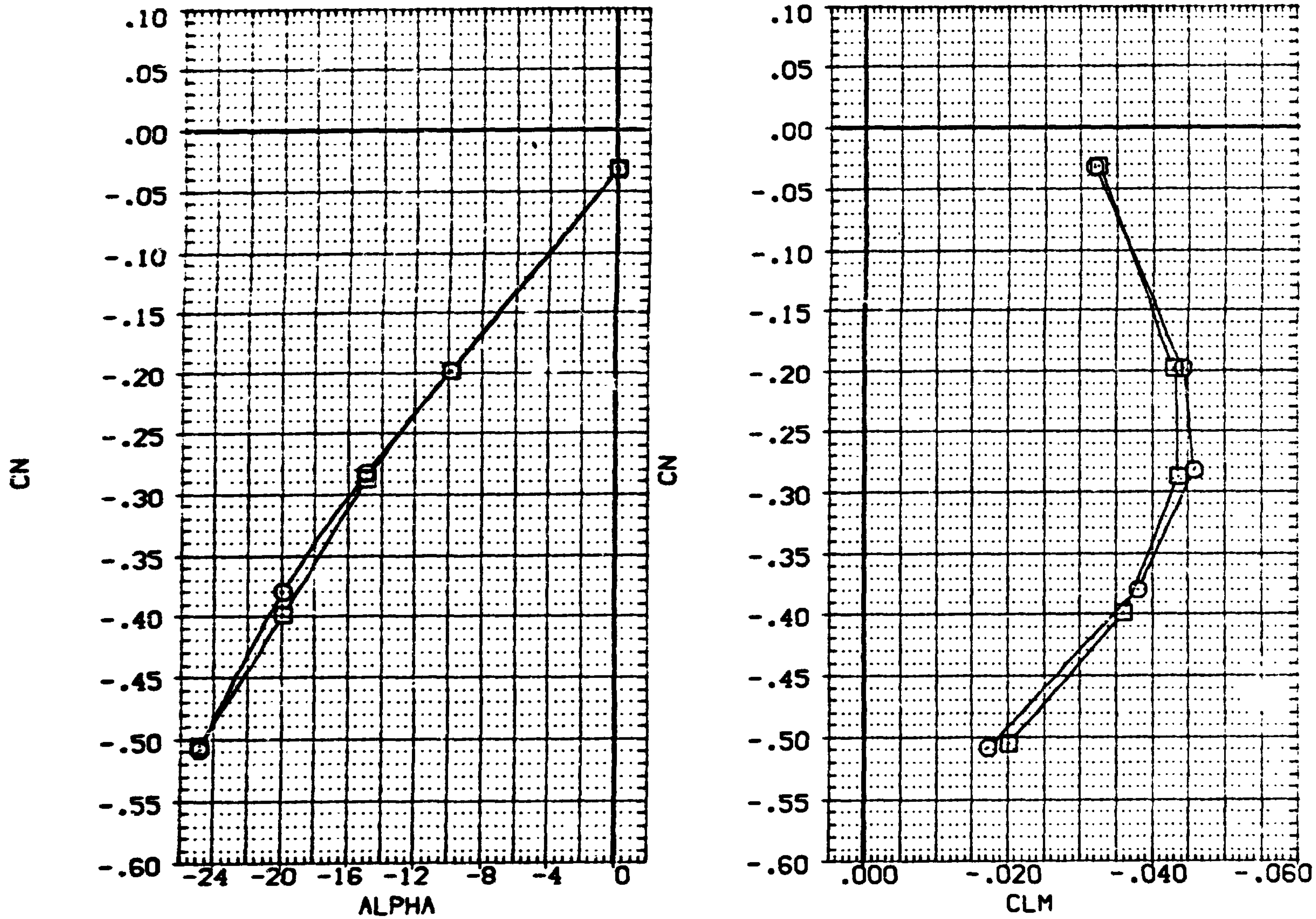


FIGURE 21. EFFECT OF ANGLE OF ATTACK ON AERO. PARAMETERS (ELEVATOR =-30)
(A)MACH = 5.94

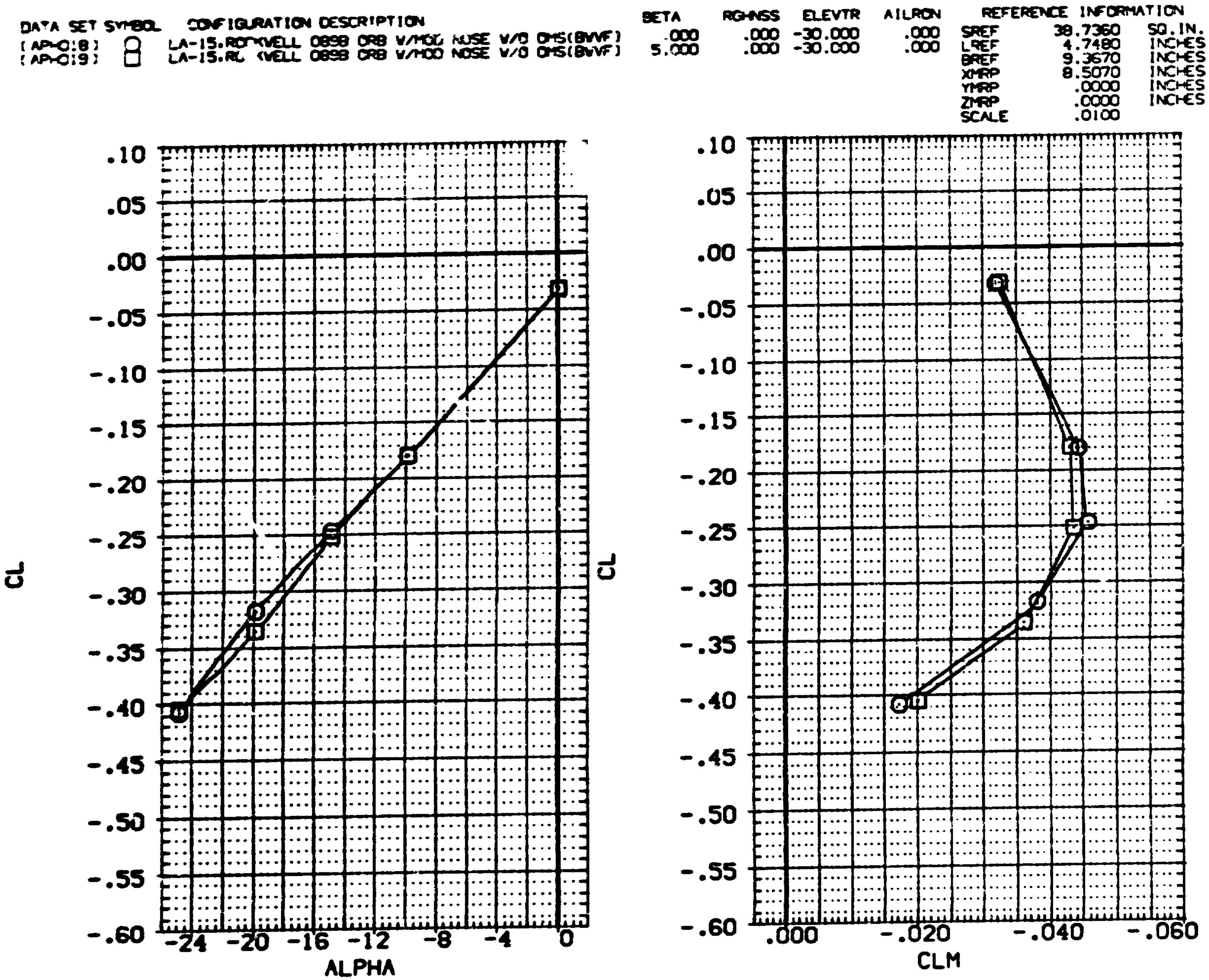


FIGURE 21. EFFECT OF ANGLE OF ATTACK ON AERO. PARAMETERS (ELEVATOR =-30)

(A)MACH = 5.94

DATA SET SYMBOL	CONFIGURATION DESCRIPTION	RGHNSS	ELEVTR	AILRON
(CPHC:8) ○	LA-15.ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BVVF)	.000	-30.000	.000

REFERENCE INFORMATION

SREF	38.7360	SQ.IN.
LREF	4.7480	INCHES
BREF	9.3670	INCHES
XMRP	8.5070	INCHES
YMRP	.0000	INCHES
ZMRP	.0000	INCHES
SCALE	.0100	

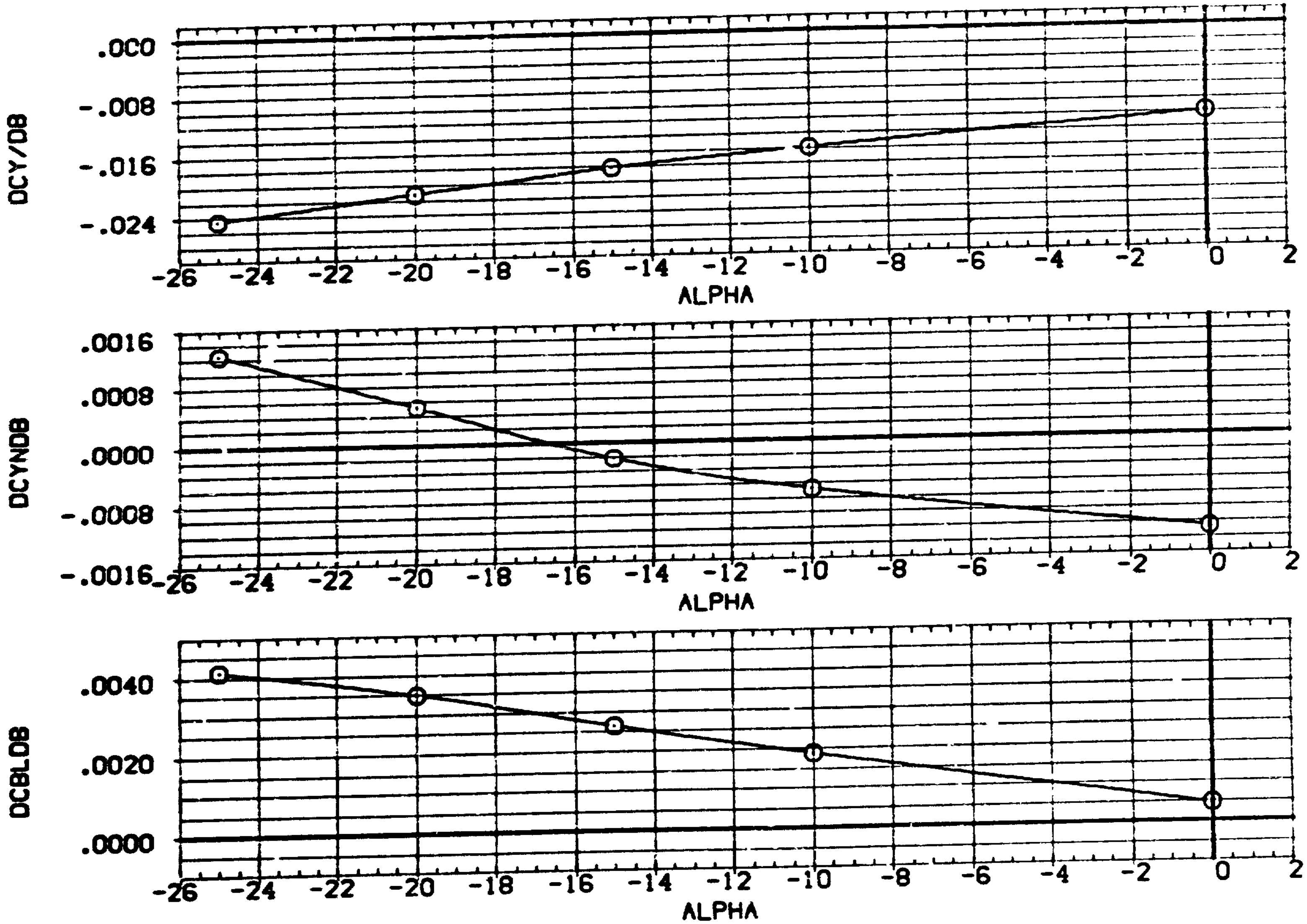


FIGURE 21. EFFECT OF ANGLE OF ATTACK ON AERO. PARAMETERS (ELEVATOR =-30)
(A)MACH = 6.00

APPENDIX

TABULATED SOURCE DATA

Plotted data are available from the DMS on request.

LA-15,ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BWVF) (RPH001) (10 JAN 74)

REFERENCE DATA

SREF = 30.7360 SQ.IN. XMRP = 8.5070 INCHES
LREF = 4.7480 INCHES YMRP = .0000 INCHES
BREF = 9.3670 INCHES ZMRP = .0000 INCHES
SCALE = .0150

PARAMETRIC DATA

BETA = .000 ELEVTR = -5.000
AILRON = -5.000 RUDDER = .000
RUDFLR = .000 RGHNSS = .000
RN/L = 9.400

RUN NO. 63/ 0 RN/L = 8.86 GRADIENT INTERVAL = -5.00/ 5.00

MACH	ALPHA	BETA	Q(PSI)	CN	CAF	CLM	CBL	CYN	CY	CAB
6.008	19.880	.00000	8.11146	.47714	.05536	-.00510	-.00357	-.00056	-.00248	.00442
5.990	24.880	.00000	8.10676	.65564	.06034	.00002	-.00417	-.00091	-.00394	.00436
5.984	29.880	.00000	8.22044	.85192	.06452	.00146	-.00478	-.00132	-.00545	.00470
5.979	34.880	.00000	8.27907	1.05439	.06786	-.00252	-.00515	-.00178	-.00587	.00475
	GRADIENT	.00000	.01073	.03880	.00083	.00018	-.00011	-.00008	-.00023	.00003

LA-15,ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BWVF) (RPH002) (10 JAN 74)

REFERENCE DATA

SREF = 30.7360 SQ.IN. XMRP = 8.5070 INCHES
LREF = 4.7480 INCHES YMRP = .0000 INCHES
BREF = 9.3670 INCHES ZMRP = .0000 INCHES
SCALE = .0100

PARAMETRIC DATA

BETA = .000 ELEVTR = -5.000
AILRON = -5.000 RUDDER = .000
RUDFLR = .000 RGHNSS = 1.000
RN/L = 9.400

RUN NO. 44/ 0 RN/L = 8.31 GRADIENT INTERVAL = -5.00/ 5.00

MACH	ALPHA	BETA	Q(PSI)	CN	CAF	CLM	CBL	CYN	CY	CAB
5.986	19.880	.00000	8.24811	.47818	.05546	-.00554	-.00390	-.00082	-.00282	.00471
5.992	24.880	.00000	6.19028	.65204	.05681	.00043	-.00465	-.00167	-.00288	.00466
6.001	29.880	.01300	7.84758	.86367	.06408	.00048	-.00533	-.00148	-.00372	.00472
6.004	34.880	.00000	7.68473	1.06424	.08804	-.00305	-.00807	-.00127	-.00535	.00453
	GRADIENT	.00000	-.03886	.03852	.00078	.00015	-.00014	-.00004	-.00017	-.00001

LA-15,ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BWVF) (RPH003) (10 JAN 74)

REFERENCE DATA

SREF = 38.7300 SQ.IN. XMRP = 6.2070 INCHES
LREF = 4.7400 INCHES YMRP = .0000 INCHES
BREF = 9.3670 INCHES ZMRP = .0000 INCHES
SCALE = .0100

PARAMETRIC DATA

BETA = -5.000 ELEVTR = -5.000
AILRON = -5.000 RUDDER = .000
RUDFLR = .000 RGHNSS = .000
RN/L = 9.400

RUN NO. 64/ 0 RN/L = 8.86 GRADIENT INTERVAL = -5.00/ 5.00

MACH	ALPHA	BETA	Q(PSI)	CN	CAF	CLM	CBL	CYN	CY	CAB
6.011	19.090	-5.00000	0.08249	.46586	.05547	-.00773	.00185	.00675	.03556	.00455
6.009	24.090	-5.00000	0.14538	.64284	.03051	-.00221	.00214	.00719	.03100	.00456
6.006	29.090	-5.00000	0.12362	.84245	.06495	-.00030	.00256	.00649	.02927	.00456
6.003	34.090	-5.00000	0.08601	1.02741	.06813	-.00287	.00293	.00582	.02700	.00450
	GRADIENT	.00000	-.00016	.03770	.00085	.00033	.00007	-.00007	-.00050	-.00000

LA-15,ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BWVF) (RPH004) (10 JAN 74)

REFERENCE DATA

SREF = 38.7300 SQ.IN. XMRP = 6.5070 INCHES
LREF = 4.7400 INCHES YMRP = .0000 INCHES
BREF = 9.3670 INCHES ZMRP = .0000 INCHES
SCALE = .0100

PARAMETRIC DATA

BETA = -5.000 ELEVTR = -5.000
AILRON = -5.000 RUDDER = .000
RUDFLR = .000 RGHNSS = 1.000
RN/L = 9.400

RUN NO. 49/ 0 RN/L = 8.80 GRADIENT INTERVAL = -5.00/ 5.00

MACH	ALPHA	BETA	Q(PSI)	CN	CAF	CLM	CBL	CYN	CY	CAB
6.016	19.090	-5.00000	0.14906	.47194	.05775	-.01140	.00015	.00741	.03489	.00486
6.011	24.090	-5.00000	0.16145	.64242	.06260	-.00880	.00014	.00813	.03086	.00485
6.006	29.090	-5.00000	0.16046	.83679	.06741	-.00499	.00030	.00779	.02898	.00484
6.002	34.090	.00000	0.19984	1.04081	.07119	-.00791	.00082	.00725	.02626	.00474
	GRADIENT	.30000	.00343	.03401	.00080	.00024	.00005	-.00002	-.00343	-.00001

LA-15,ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BWVF) (RPH005) (10 JAN 74)

REFERENCE DATA

SREF = 38.7360 SQ.IN. XMRP = 8.5070 INCHES
LREF = 4.7480 INCHES YMRP = .0000 INCHES
BREF = 9.3670 INCHES ZMRP = .0000 INCHES
SCALE = .0100

PARAMETRIC DATA

BETA = .000 ELEVTR = 10.000
AILRON = 4.000 RUDDER = .000
RUDFLR = .000 RGHNSS = .000
RN/L = 9.400

RUN NO. 59/ 0 RN/L = 8.80 GRADIENT INTERVAL = -5.00/ 5.00

MACH	ALPHA	BETA	Q(PSI)	CN	CAF	CLM	CBL	CYN	CY	CAB
6.002	19.090	.00000	8.15932	.49083	.05968	-.02385	.00073	-.00179	-.00210	.00446
5.998	24.090	.00000	8.18157	.68403	.06659	-.02366	.00123	-.00247	-.00351	.00438
5.995	29.090	.00000	8.20438	.88758	.07274	-.02752	.00180	-.00327	-.00524	.00461
5.989	34.090	.00000	8.23471	1.10109	.07849	-.03503	.00195	-.00403	-.00730	.00466
	GRADIENT	.00000	.00498	.04021	.00125	-.00075	.00008	-.00015	-.00035	.00002

LA-15,ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BWVF) (RPH006) (10 JAN 74)

REFERENCE DATA

SREF = 38.7360 SQ.IN. XMRP = 8.5070 INCHES
LREF = 4.7480 INCHES YMRP = .0000 INCHES
BREF = 9.3670 INCHES ZMRP = .0000 INCHES
SCALE = .0100

PARAMETRIC DATA

BETA = .000 ELEVTR = 10.000
AILRON = 4.000 RUDDER = .000
RUDFLR = .000 RGHNSS = 1.000
RN/L = 9.400

RUN NO. 53/ 0 RN/L = 8.75 GRADIENT INTERVAL = -5.00/ 5.00

MACH	ALPHA	BETA	Q(PSI)	CN	CAF	CLM	CBL	CYN	CY	CAB
6.002	19.090	.00000	8.23402	.50120	.06064	-.02429	.00070	-.00172	-.00452	.00447
5.994	24.090	.00000	8.18649	.68013	.06705	-.02379	.00119	-.00235	-.00603	.00437
5.986	29.090	.00000	8.25730	.88297	.07313	-.02790	.00190	-.00296	-.00768	.00467
5.984	34.090	.00000	8.38008	1.10731	.07934	-.03636	.00224	-.00389	-.01013	.00470
	GRADIENT	.00000	.00974	.04042	.00124	-.00081	.00011	-.00013	-.00037	.00002

LA-15,ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BWVF) (RPH007) (10 JAN 74)

REFERENCE DATA

SREF = 38.7360 SQ.IN. XMRP = 8.5070 INCHES
LREF = 4.7480 INCHES YMRP = .0000 INCHES
BREF = 9.3670 INCHES ZMRP = .0000 INCHES
SCALE = .0100

PARAMETRIC DATA

BETA = -5.000 ELEVTR = 10.000
AILRON = 4.000 RUDDER = .000
RUDFLR = .000 RGHNSS = .000
RN/L = 9.400

RUN NO. 60/ 0 RN/L = 8.86 GRADIENT INTERVAL = -5.00/ 5.00

MACH	ALPHA	BETA	Q(PSI)	CN	CAF	CLM	CBL	CYN	CY	CAB
6.011	19.890	-5.00000	8.12301	.49107	.06027	-.02593	.00639	.00543	.03673	.00460
6.009	24.890	-5.00000	8.14535	.67419	.06673	-.02549	.00763	.00563	.03200	.00460
6.004	29.890	-5.00000	8.10727	.87704	.07287	-.02811	.00915	.00470	.03030	.00459
6.001	34.890	-5.00000	8.17514	1.07595	.07845	-.03489	.01055	.00354	.02915	.00449
	GRADIENT	.00000	.00237	.03915	.00121	-.00059	.00028	-.00013	-.00049	-.00001

LA-15,ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BWVF) (RPH008) (10 JAN 74)

REFERENCE DATA

SREF = 38.7360 SQ.IN. XMRP = 8.5070 INCHES
LREF = 4.7480 INCHES YMRP = .0000 INCHES
BREF = 9.3670 INCHES ZMRP = .0000 INCHES
SCALE = .0100

PARAMETRIC DATA

BETA = -5.000 ELEVTR = 10.000
AILRON = 4.000 RUDDER = .000
RUDFLR = .000 RGHNSS = 1.000
RN/L = 9.400

RUN NO. 54/ 0 RN/L = 8.86 GRADIENT INTERVAL = -5.00/ 5.00

MACH	ALPHA	BETA	Q(PSI)	CN	CAF	CLM	CBL	CYN	CY	CAB
6.008	19.890	-5.00000	8.16342	.49174	.06081	-.02639	.00629	.00550	.03476	.00461
6.008	24.890	-5.00000	8.16955	.66576	.06697	-.02594	.00758	.00581	.02995	.00457
6.002	29.890	-5.00000	8.19762	.87570	.07352	-.02905	.00921	.00499	.02771	.00459
6.000	34.890	-5.00000	8.22834	1.07554	.07897	-.03590	.01067	.00386	.02555	.00449
	GRADIENT	.00000	.00446	.03923	.00122	-.00063	.00030	-.00011	-.00060	-.00001

LA-15,ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BWVF) (RPH009) (10 JAN 74)

REFERENCE DATA

SREF = 38.7360 SQ.IN. XMRP = 8.5070 INCHES
LREF = 4.7480 INCHES YMRP = .0000 INCHES
BREF = 9.3670 INCHES ZMRP = .0000 INCHES
SCALE = .0100

PARAMETRIC DATA

BETA = .000 ELEVTR = -5.000
AILRON = -5.000 RUDDER = .000
RUDFLR = .000 RGHNSS = .000
RN/L = 4.000

RUN NO. 67/ 0 RN/L = 3.95 GRADIENT INTERVAL = -5.00/ 5.00

MACH	ALPHA	BETA	Q(PSI)	CN	CAF	CLM	CBL	CYN	CY	CAB
5.930	19.890	.00000	3.57107	.48273	.04564	-.00240	-.00364	-.00033	-.00429	.00443
5.935	24.890	.00000	3.56771	.66054	.04960	.00278	-.00421	-.00092	-.00562	.00443
5.937	29.890	.00000	3.57404	.86195	.05454	.00304	-.00480	-.00152	-.00733	.00451
	GRADIENT	.00000	.00030	.03792	.00089	.00054	-.00012	-.00012	-.00030	.00001

LA-15,ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BWVF) (RPH010) (10 JAN 74)

REFERENCE DATA

SREF = 30.7360 SQ.IN. XMRP = 8.5070 INCHES
LREF = 4.7480 INCHES YMRP = .0000 INCHES
BREF = 9.3670 INCHES ZMRP = .0000 INCHES
SCALE = .0100

PARAMETRIC DATA

BETA = .000 ELEVTR = -5.000
AILRON = -5.000 RUDDER = .000
RUDFLR = .000 RGHNSS = 1.000
RN/L = 4.000

RUN NO. 47/ 0 RN/L = 3.65 GRADIENT INTERVAL = -5.00/ 5.00

MACH	ALPHA	BETA	Q(PSI)	CN	CAF	CLM	CBL	CYN	CY	CAB
5.947	19.890	.00000	3.54976	.49076	.04959	-.00462	-.00409	-.00015	-.00421	.00486
5.949	24.890	.00000	3.49016	.66510	.05041	.00199	-.00482	-.00122	-.00452	.00489
5.953	29.890	.00000	3.50531	.86747	.04528	.00378	-.00577	-.00376	-.00434	.00488
	GRADIENT	.00000	-.00444	.03767	-.00043	.00084	-.00017	-.00036	-.00001	.00000

LA-15,ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BWVF) (RPH011) (10 JAN 74)

REFERENCE DATA

SREF = 30.7360 SQ.IN. XMRP = 8.5070 INCHES
LREF = 4.7480 INCHES YMRP = .0000 INCHES
BREF = 9.3670 INCHES ZMRP = .0000 INCHES
SCALE = .0100

PARAMETRIC DATA

BETA = -5.000 ELEVTR = -5.000
AILRON = -5.000 RUDDER = .000
RUDFLR = .000 RGHNSS = .000
RN/L = 4.000

RUN NO. 68/ 0 RN/L = 3.78 GRADIENT INTERVAL = -5.00/ 5.00

MACH	ALPHA	BETA	Q(PSI)	CN	CAF	CLM	CBL	CYN	CY	CAB
5.953	19.890	-5.00000	3.47817	.47303	.04552	-.00584	.00188	.00710	.03255	.00459
5.955	24.890	-5.00000	3.47810	.65028	.05004	-.00027	.00240	.00731	.02865	.00455
5.958	29.890	-5.00000	3.48864	.85048	.05370	.00181	.00281	.00668	.02798	.00438
	GRADIENT	.00000	.00105	.03775	.00082	.00077	.00009	-.00004	-.00046	-.00002

LA-15,ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BWVF) (RPH012) (10 JAN 74)

REFERENCE DATA

SREF = 30.7360 SQ.IN. XMRP = 8.5070 INCHES
LREF = 4.7480 INCHES YMRP = .0000 INCHES
BREF = 9.3670 INCHES ZMRP = .0000 INCHES
SCALE = .0100

PARAMETRIC DATA

BETA = -5.000 ELEVTR = -5.000
AILRON = -5.000 RUDDER = .000
RUDFLR = .000 RGHNSS = 1.000
RN/L = 4.000

RUN NO. 52/ 0 RN/L = 3.45 GRADIENT INTERVAL = -5.00/ 5.00

MACH	ALPHA	BETA	Q(PSI)	CN	CAF	CLM	CBL	CYN	CY	CAB
5.944	19.890	-5.00000	3.56666	.47870	.04808	-.00667	.00143	.00689	.03506	.00517
5.949	24.890	-5.00000	3.48797	.64831	.05281	.00001	.00166	.00740	.03201	.00508
5.953	29.890	-5.00000	3.46889	.85478	.05707	.00290	.00209	.00655	.03254	.00500
	GRADIENT	.00000	-.00998	.03761	.00090	.00096	.00007	-.00003	-.00025	-.00002

LA-15,ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BWF) (RPH013) (10 JAN 74)

REFERENCE DATA

SREF = 30.7360 SQ.IN. XMRP = 8.5070 INCHES
LREF = 4.7480 INCHES YMRP = .0000 INCHES
BREF = 9.3670 INCHES ZMRP = .0000 INCHES
SCALE = .0100

PARAMETRIC DATA

BETA = .000 ELEVTR = 10.000
AILRON = 4.000 RUDDER = .000
RUDFLR = .000 RGHNSS = .000
RN/L = 4.000

RUN NO. 62/ 0 RN/L = 3.57 GRADIENT INTERVAL = -5.00/ 5.00

MACH	ALPHA	BETA	Q(PSI)	CN	CAF	CLM	CBL	CYN	CY	CAB
5.953	19.890	.00000	3.51919	.50279	.05138	-.02287	.00110	-.00177	-.00232	.00455
5.955	24.890	.00000	3.47775	.69294	.05736	-.02250	.00165	-.00253	-.00342	.00447
5.960	29.890	.00000	3.45027	.89985	.06776	-.02678	.00226	-.00344	-.00506	.00450
	GRADIENT	.00000	-.00689	.03971	.00124	-.00039	.00012	-.00017	-.00027	-.00001

LA-15,ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BWF) (RPH014) (10 JAN 74)

REFERENCE DATA

SREF = 30.7360 SQ.IN. XMRP = 8.5070 INCHES
LREF = 4.7480 INCHES YMRP = .0000 INCHES
BREF = 9.3670 INCHES ZMRP = .0000 INCHES
SCALE = .0100

PARAMETRIC DATA

BETA = .000 ELEVTR = 10.000
AILRON = 4.000 RUDDER = .000
RUDFLR = .000 RGHNSS = 1.000
RN/L = 4.000

RUN NO. 57/ 0 RN/L = 3.67 GRADIENT INTERVAL = -5.00/ 5.00

MACH	ALPHA	BETA	Q(PSI)	CN	CAF	CLM	CBL	CYN	CY	CAB
5.945	19.890	.00000	3.58703	.51330	.05467	-.02352	.00089	-.00189	-.00203	.00431
5.950	24.890	.00000	3.54143	.69884	.06170	-.02397	.00142	-.00274	-.00324	.00425
5.955	29.890	.00000	3.49374	.90108	.06769	-.02829	.00180	-.00367	-.00496	.00432
	GRADIENT	.00000	-.00933	.03378	.00130	-.00028	.00009	-.00018	-.00029	.00000

LA-15,ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BWF) (RPH015) (10 JAN 74)

REFERENCE DATA

SREF = 30.7360 SQ.IN. XMRP = 8.5070 INCHES
LREF = 4.7480 INCHES YMRP = .0000 INCHES
BREF = 9.3670 INCHES ZMRP = .0000 INCHES
SCALE = .0100

PARAMETRIC DATA

BETA = -5.000 ELEVTR = 10.000
AILRON = 4.000 RUDDER = .000
RUDFLR = .000 RGHNSS = .000
RN/L = 4.000

RUN NO. 61/ 0 RN/L = 3.61 GRADIENT INTERVAL = -5.00/ 5.00

MACH	ALPHA	BETA	Q(PSI)	CN	CAF	CLM	CBL	CYN	CY	CAB
5.952	19.890	-5.00000	3.48285	.50856	.05157	-.02538	.00692	.00580	.03500	.00472
5.956	24.890	-5.00000	3.53230	.69057	.05799	-.02480	.00820	.00568	.02993	.00461
5.956	29.890	-5.00000	3.42873	.88522	.06307	-.02720	.00980	.00469	.02981	.00445
	GRADIENT	.00000	-.00541	.03767	.00115	-.00018	.00029	-.00011	-.00052	-.00003

LA-15,ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BWVF) (RPH016) (10 JAN 74)

REFERENCE DATA

SREF = 38.7380 SQ.IN. XMRP = 8.5070 INCHES
LREF = 4.7480 INCHES YMRP = .0000 INCHES
BREF = 9.3670 INCHES ZMRP = .0000 INCHES
SCALE = .0100

PARAMETRIC DATA

BETA = -5.000 ELEVTR = 10.000
AILRON = 4.000 RUDDER = .000
RUDFLR = .000 RGHNSS = 1.000
RN/L = 4.000

RUN NO. 58/ 0 RN/L = 3.75 GRADIENT INTERVAL = -5.00/ 5.00

MACH	ALPHA	BETA	Q(PSI)	CN	CAF	CLM	CBL	CYN	CY	CAB
5.951	19.090	-5.00000	3.49131	.50618	.05479	-.02644	.00652	.00571	.03609	.00457
5.995	24.090	-5.00000	3.45425	.68229	.06113	-.02548	.00787	.00577	.03214	.00444
5.999	29.090	-5.00000	3.55158	.86882	.06807	-.02716	.00937	.00458	.03176	.00435
	GRADIENT	.00000	.00603	.03827	.00133	-.00007	.00029	-.00011	-.00043	-.00002

LA-15,ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BWVF) (RPH017) (10 JAN 74)

REFERENCE DATA

SREF = 38.7380 SQ.IN. XMRP = 8.5070 INCHES
LREF = 4.7480 INCHES YMRP = .0000 INCHES
BREF = 9.3670 INCHES ZMRP = .0000 INCHES
SCALE = .0100

PARAMETRIC DATA

BETA = .000 ELEVTR = -5.000
AILRON = -5.000 RUDDER = .000
RUDFLR = .000 RGHNSS = .000
RN/L = 4.000

RUN NO. 75/ 0 RN/L = 3.90 GRADIENT INTERVAL = -5.00/ 5.00

MACH	ALPHA	BETA	Q(PSI)	CN	CAF	CLM	CBL	CYN	CY	CAB
5.953	-24.080	.00000	3.50057	-.47498	.09769	-.06123	-.00408	-.00031	.00231	.00250
5.943	-19.890	.00000	3.55169	-.38273	.09233	-.07090	-.00340	-.00012	.00241	.00337
5.954	-14.890	.00000	3.58548	-.27628	.08438	-.07305	-.00279	-.00004	.00271	.00379
5.945	-9.890	.00000	3.50800	-.20745	.07859	-.08322	-.00232	-.00008	.00280	.00401
5.940	.110	.00000	3.52857	-.05691	.06256	-.03892	-.00217	.00019	.00191	.00424
	GRADIENT	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

LA-15,ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BWVF) (RPH018) (10 JAN 74)

REFERENCE DATA

SREF = 38.7360 SQ.IN. XMRP = 8.5070 INCHES
LREF = 4.7480 INCHES YMRP = .0000 INCHES
BREF = 9.3670 INCHES ZMRP = .0000 INCHES
SCALE = .0100

PARAMETRIC DATA

BETA = .000 ELEVTR = -30.000
AILRON = .000 RUDDER = .000
RUDFLR = .000 RGHNSS = .000
RN/L = 4.000

RUN NO. 78/ 0 RN/L = 3.82 GRADIENT INTERVAL = -5.00/ 5.00

MACH	ALPHA	BETA	Q(PSI)	CN	CAF	CLM	CBL	CYN	CY	CAB
5.940	-24.090	.00000	3.68702	-.50849	.12746	-.01727	-.00096	.00076	.00174	.00103
5.940	-19.090	.00000	3.59199	-.37928	.11263	-.03804	-.00100	.00056	.00203	.00256
5.940	-14.090	.00000	3.49437	-.28197	.09993	-.04580	-.00126	.00035	.00269	.00299
5.940	-9.090	.00000	3.54383	-.19802	.08869	-.04433	-.00127	.00031	.00299	.00361
5.940	.110	.00000	3.60729	-.03198	.06546	-.03194	-.00172	.00028	.00203	.00408
	GRADIENT	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

LA-15,ROCKWELL 089B ORB W/MOD NOSE W/O OMS(BWVF) (RPH019) (10 JAN 74)

REFERENCE DATA

SREF = 38.7360 SQ.IN. XMRP = 8.5070 INCHES
LREF = 4.7480 INCHES YMRP = .0000 INCHES
BREF = 9.3670 INCHES ZMRP = .0000 INCHES
SCALE = .0100

PARAMETRIC DATA

BETA = 5.000 ELEVTR = -30.000
AILRON = .000 RUDDER = .000
RUDFLR = .000 RGHNSS = .000
RN/L = 4.000

RUN NO. 80/ 0 RN/L = 3.68 GRADIENT INTERVAL = -5.00/ 5.00

MACH	ALPHA	BETA	Q(PSI)	CN	CAF	CLM	CBL	CYN	CY	CAB
5.940	-24.090	5.00000	3.57898	-.50486	.12630	-.02027	.01957	.00694	-.11977	.00129
5.940	-19.090	5.00000	3.50576	-.39857	.11477	-.03611	.01636	.00305	-.10327	.00227
5.940	-14.090	5.00000	3.5260	-.28767	.09997	-.04373	.01188	-.00084	-.08749	.00330
5.940	-9.090	5.00000	3.47582	-.19716	.08749	-.04315	.00804	-.00312	-.07579	.00387
5.940	.110	5.00000	3.53667	-.03170	.06572	-.03238	.00045	-.00604	-.05693	.00418
	GRADIENT	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000